SCIENTIFIC AMERICAN

No. SUPPLEMENT 178

Scientific American Supplement, Vol. VII., No. 178.
Scientific American, established 1845.

NEW YORK, MAY 31, 1879.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

RAILWAY VELOCIPEDES.

OUR first engraving illustrates a curious amateur vehicle, made by a schoolmaster in Pennsylvania for his personal convenience. It might be called a sort of flying machine. The *Sentinel*, of Lewistown, Pa., thus describes the apparatus:

"When velocipedes were in vogue those with three wheels were termed tricycles, with two wheels bicycles, and it was a standing joke to predict one-wheeled vehicles and style them icycles. Several elaborate attempts have been noticed in the papers, but all were expensive and practically useless, until at last one of our sister county's geniuses has accomplished the task, and at a cost of simply a few pieces of board and scraps of iron, such as may be picked up about any barnyard.

"The inventor is Mr. J. O. Kaempfer, living near Adamsburg, who, having obtained the position of teacher at the McClure school, designed the machine to transport himself from his home to the school and back on the railroad track, a distance of five miles each way.

"The driving wheel is of one inch board and 20 in. in diameter, running in a slot cut through a piece of board that just clears the track. Two pieces of board support a small seat right over the wheel, and serve to carry the axle of the wheel with a crank, on the inner end. A small roller in the board steadies it frontways, and a stick across to the other rail, terminating in another roller, sideways. A wooden pitman connected to the crank, playing between the operator's legs, is the means of propulsion. The weight as it stands on the rail is 28 lbs. An average speed of six miles per hour could easily be maintained, and in places as high as ten, perhaps twelve miles per hour could be attained.

"The owner running it on the road without permission, and several times nearly at the cost of his life, on account of the uncertainty of the extra trains, Supt. Edward B. Taylor was obliged to order its capture. Crude and rough as it is, it does remarkably well, and shows lots of mother wit for the owner.

"The large driving wheel had a leather strap nailed to its periphery to increase the adhesion. The handle was fastened to the crank by a strip bolted on one side, and motion was produced by raising and lowering the handle like an old-fashioned churn. The machine was held on the track by a horizontal wheel on the inside of the rail (shown on the right side of engraving) and a peg on the outside of the same rail. A roller was attached to the end of the arm, which rested on the opposite rail."

Another form of vehicle in this line is that of Mr. G. S. Sheffield, of Three Rivers, Mich., which is described as follows in the *Railroad Gazette:*

"It is a three-wheeled vehicle, and the smallest of the wheels is placed at one end of a bar that is fastened to the left hand rail to keep the vehicle upright and upon the track. The other two wheels, of which that in the rear is the largest, rest upon the right hand rail, and over them is built a framework that answers for a seat and carrying place. The power is applied from a lever in front, worked by hand alone or by hand and foot, and connected with two cog-wheels which act on cogs in the shaft of the hindmost wheel upon the track. The whole is put together in a very neat and substantial shape, and nicely finished. They are used by railroad officials in repairing telegraph lines, measuring wood, and various kinds of light work, and going twelve miles an hour without any extra effort. The Michigan Central, Lake Shore & Michigan Southern, Michigan Lake Shore, Port Huron, Grand Rapids & Indiana, and Lawton & Paw Paw railways use them, the last named to carry the mail on the narrow gauge road between those two places. Mr. S. lately sent one on an order for three from the Chicago, Alton & St. Louis Railway, and expects an order for five from the Canada Southern."

KAEMPFER'S RAILWAY VELOCIPEDE.

SHEFFIELD'S RAILWAY VELOCIPEDE.

THE CRIME OF INVENTING MACHINERY.

PERHAPS the most plausible and practical grievance set forth by the workingmen before the Congressional Labor Investigating Committee, and indorsed by our own correspondent, G. V. Smith, a workingman, in a letter to the paper, is the use of machinery in place of hand labor. This grievance has been always a favorite one with the working classes. It looks so true at first sight—it is so true in its first operation—that it requires more wisdom and experience than usually falls to the lot of what we may be permitted to call the "impulsive classes" to see how false the policy of an organized opposition to machinery would be in the long run. We recollect the riots of Jack Swing in England in 1829, when thrashing machines were supposed to take bread (as they actually did for a time) out of the mouths of the agricultural laborers. Suppose reapers, thrashers, and steam plows had been forbidden by international laws at that period, should we have family flour in 1878 from $5.25 to $6.50 a barrel? The great grain lands of the West, which feed the hungry over the world, and give employment to hundreds of thousands of workmen, who assist in getting the grain to the consumer, are made available only by agricultural machines.

Again, we recollect when a small child being very miserable by an article read aloud in our presence from one of the English reviews, describing the total decay of the race of horses that must inevitably result from the introduction of railroads. We were born with a love for horses—it was horrible to think that they would soon be as extinct as the mammoth; we cried when we went to bed. The practical result of railroad enterprises has been that a hundred horses are employed to one that was needed in the days when all internal traffic was carried on by turnpikes, canals, or rivers. How would millions of workingmen earn their bread to-day had those opposed to the first railroad succeeded in making their case good before the proposed Bureau of Labor, authorized to make the invention of a steam engine "an offense punishable by law"? In the English parliament fifty-three years ago, Rear-Admiral Sir Isaac Coffin, an American born, made a speech in the interests of workingmen against the introduction of railroads. "He would not consent," he said, "to see widows' premises and shrubbery beds invaded; and what, he should like to know, was to be done with all those who had advanced money in making and repairing turnpike roads? What was to become of coach-makers, harness-makers, coach-masters and coachmen, inn-keepers, horse-breeders and horse-dealers? Was the House aware of the smoke and the noise, the hiss and the whirl which locomotive engines, passing at the rate of ten or twelve miles an hour, would occasion? Cattle plowing in the fields or grazing in the meadows could not behold them without dismay. Iron would be raised in price 100 per cent., or, more probably, exhausted altogether."

But the great railroad question, with its attendant interests, is so vast that perhaps we may best serve our present purpose by presenting some facts concerning the sewing machine.

Sewing machines may be said to have come into practical use about thirty years ago. Foreigners claim that the originator of the idea was a Frenchman named Thimonier, but his discovery never became practical, and Elias Howe, our own countryman, is acknowledged by the world to be the inventor of sewing machines. It was estimated last year that there were 4,000,000,000 of sewing machines in the world. In England alone, the mere production of machines employs 100,000 persons, and in the United States probably 200,000 are so employed. There is no question as to the comfort and economy of sewing machines in families, but there were grave doubts in the minds of philanthropists whether they might not injure the business of poor women—those who, by making dresses, pants, coats, wrappings, and shirts, could not, even by working fourteen hours a day, make more than a bare living. But the invention of the sewing machine has ameliorated the condition of sewing women. The "Song of the Shirt" has ceased; the shirts are made more rapidly and more cheaply than before; the work is better paid, and the hours of labor diminished. As clothes increase in cheapness more material is employed. Each machine requires hands to cut out and prepare sewing. Numbers of women became capitalists by owning a machine, and the machine, more than any efforts of philanthropy, has made an opening for female industry. Indeed, in England it is accused of having led to a scarcity of domestic servants, and an extraordinary rise in their wages.

Let us take the history of one branch of industry as affected by the sewing machine. In 1857 a sewing machine for sewing leather was introduced at Northampton, the Lynn of England, the center of the shoe trade. It immediately led to an organized opposition on the part of journeymen shoemakers. In February, 1859, the master manufacturers formed themselves into a league, pledging themselves to introduce the use of machines into their trade in spite of their

workmen. They carried their point. In a short time the operatives became eager to possess machines of their own, which were mainly worked by the women of their households. It is now estimated that at least one-half of the Northampton manufacturers have risen from being journeymen shoe-makers by means of the machine industry.

Happily neither a labor bureau nor the trades unions have as yet intermeddled with the sewing machine. Its affairs have been settled between employers and working people wholly by the operation of natural causes. The result has been that the earnings of the skilled and intelligent have risen from fifty to one hundred per cent., while middling and inferior work is paid in its proportion. In other branches of industry injustice is continually done to what may be called the "upper class" of working people by the unwritten law of the country, which entitles the unskillful and unfaithful and the half-trained to demand and expect the same wages as those who know and do their business thoroughly. With us the young girl, for instance, "takes a place" without any preparation and expects the highest wages. She "could not think of taking less," or if she does, she "takes it out of you" either in idleness, discontent, or privileges.

Happily no such conditions accompanied the introduction of the sewing machine. Labor, with its assistants, commands on the whole what it is worth, and the increased amount of wealth arising from the introduction of the sewing machine has been equitably and wholesomely distributed among the public, its main good falling to the working classes. The use of the machine in household labor is especially adapted to American women. Their neat-handed industry fits them to deal with its delicacies and idiosyncrasies, for machines, like human creatures, seem to have their individuality, and are endowed with characters, if not with souls. Sometimes, indeed, there seems to pass into them an evil spirit; they become actually "possessed of the devil," and are more trying to female nerves and tempers than St. Anthony's temptation to the hermit's soul.

We should deprecate their superseding hand needlework altogether in families, for needlew ork to women is the sedative that tobacco is supposed to be to men; but fortunately a great deal of work has to be made ready for the machine, and a great deal is finished off by old-fashioned hand sewing.

Elias Howe made, we believe, more money by his patent than has been made by any other inventor. We are glad the patent has run out, and that now his "happy thought" will become further serviceable to overworked humanity, but assuredly till the dawn of a new light during the past ten days we never considered him as one who should be "branded with the infamy of criminal imprisonment," or even be begrudged the millions he has won. He has done more real service to women than legislators or philanthropists, but it is only when some volume of statistics turns public attention to the subject that we are able to appreciate how widespread is the blessing that his household fairy (in spite of occasional tantrum) has conferred.—*Baltimore American.*

[Continued from SUPPLEMENT No. 176, page 2798.]

SKEW-BEVEL WHEELS.

By Prof. C. W. MACCORD.

No. 3.—Special and Singular Relations of Pitch-Surfaces.

IT has been pointed out that it is, in many cases, practicable to employ at the same time two equal and similar pairs of skew-bevel wheels, on opposite sides of the gorge planes, as represented in Fig. 12.

This, however, it was also stated, is not always possible; and we come now to consider when and why it is not. There is so close an analogy between the cone and the hyperboloid (of which in fact the cone may be considered as the limiting form in one direction, the distance between the axes being reduced to zero), that it may throw light upon the matter in hand, if we first examine the corresponding situations in relation to bevel gearing.

In Fig. 17, the frusta, A, C, are cut from the opposite nappes of the same cone, and are equidistant from the vertex. This cone is tangent along the element, *o p*, to another whose axis is inclined, from which are cut the frusta, B, D, also from the opposite nappes and equidistant from the vertex.

It will be observed that the frusta are tangent along the same line, and along one line only; also that the directional relations of the rotations of the two pairs are the same, as shown by the arrows. Under these circumstances, two of the wheels, as B, D, may be fixed on the same shaft; the other two, A, C, turn in the same direction with the same velocity, and have the same axis, although the shaft must be cut, because both shafts cannot be carried past the vertex of the cones.

In Fig. 18 the axes intersect at right angles; and in this case it will be noticed that the cones have two elements of tangency, *o p* and *m n*. The frustum, B, may roll with both A and C at the same time, but those two will turn in opposite directions, and the one corresponding to D, in the preceding figure, must be omitted.

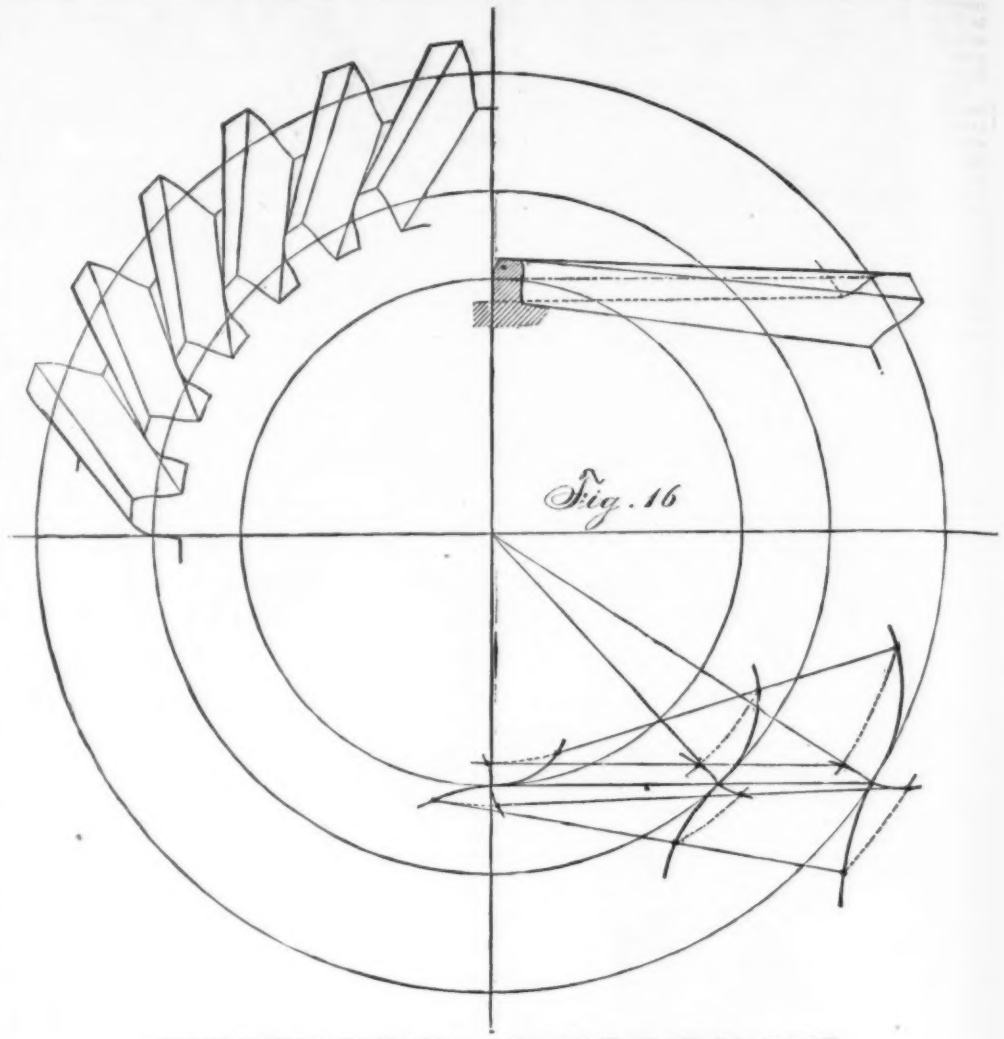
That, however, is because the two pairs are thus far supposed to be equal and equidistant from the vertex. As shown in Fig. 19, two wheels, B, D, may be fixed upon one shaft, the frusta being cut from opposite nappes of the cones, but unequally distant from the vertex, and the rotations of A and C will have the same direction and velocity; it is to be noted that both pairs have but one and the same line of tangency, in this case *o p*. Two pairs might have been used tangent along *m n*, D engaging with A, and B with C, in which case the directional relations would have been reversed, while the velocity ratio would remain the same.

It will, therefore, be seen that the more nearly perpendicular to each other the axes are the closer is the approach to this condition of double tangency. And as in practice the wheels must have teeth, it is also evident that equal and similar pairs cannot be used in all cases, even when the axes are not perpendicular to each other, because although the pitch cones touch along only one line, they may be so close together on the opposite sides that the teeth will interfere with each other.

If, now, we suppose the inclined axis in Fig. 17 to lie, not in the plane of the paper, but in front of and parallel to it, we shall have exactly the state of things shown in Fig. 11; and, if this lateral separation of the axes be great enough, we can carry the shafts past each other, and as shown in the preceding article in connection with that figure, we may use two similar and equal pairs fixed on the same shafts. But if we make the same supposition in regard to the horizontal axis in Fig. 18, we shall still be confronted by a situation analogous to that represented in that figure and just explained. Instead of cones we shall have hyperboloids, it is true; but as shown in Fig. 20, they will still be tangent along two lines. And it is clear that no rotation of either pitch-surface will cause the other to turn, for the simple reason that it cannot turn both ways at once, and the two elements of contact tend to act in opposite directions. That is, if they be extended on both sides of the gorge planes. But as shown in Fig. 21, we can cut frusta from these surfaces, on either side of the gorge planes, which will transmit rotation, the velocity ratio being the same, however the frusta are situated, but the directional relation depending on which one of the two elements of tangency is selected, all precisely as in the case of the conical frusta of Fig. 18. And in Fig. 22 it is seen that two pairs of frusta may be used, and fixed upon the shafts, which by reason of the lateral separation of the axes can now be carried past each other, provided that one pair be far enough from the gorge planes to clear the other pair.

The impossibility of using two equal pairs symmetrically situated with respect to the gorge circles, however, is not the only nor the most remarkable circumstance due to the double tangency of the pitch-surfaces in Fig. 20. For it is obvious that if, as there shown, the hyperboloids are limited by transverse planes on opposite sides of the gorge planes, they will be tangent along both generatrices, *m n* and *o p*, no matter how near the limiting planes may be to the gorge circles. The result of this is that in this case, in which the projections of the two axes on a plane parallel to both are perpendicular to each other, it is not possible to make use of a pair of wheels of this kind, whose mid-planes are those of the gorge circles, like the central pair in Fig. 12.

We say of this class: for a pair of wheels can be made, whose central planes are thus situated, which will work correctly together, and in general appearance they resemble the skew-bevel wheels. But a closer examination will show that they belong to the class of screw wheels, of which the common endless screw, or worm and wheel, is a familiar example. When the wheels of that kind which most nearly



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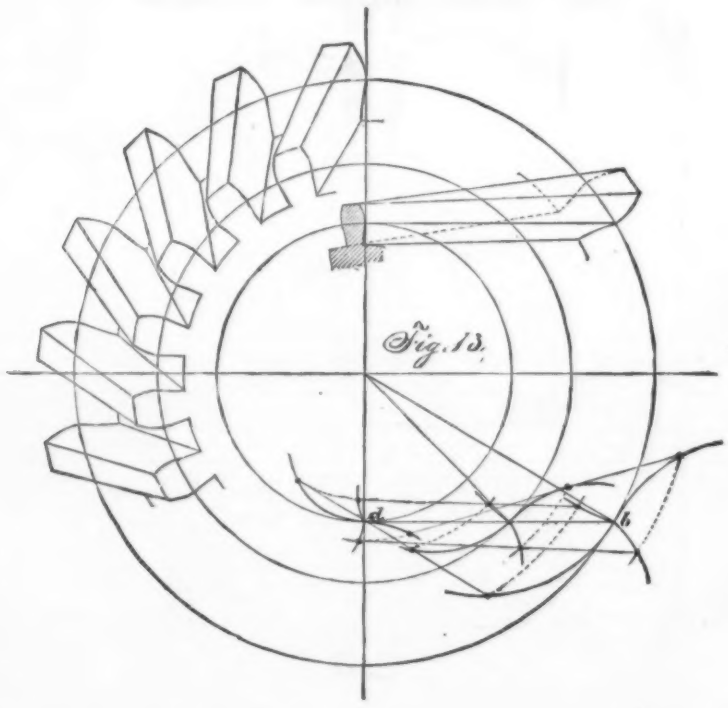
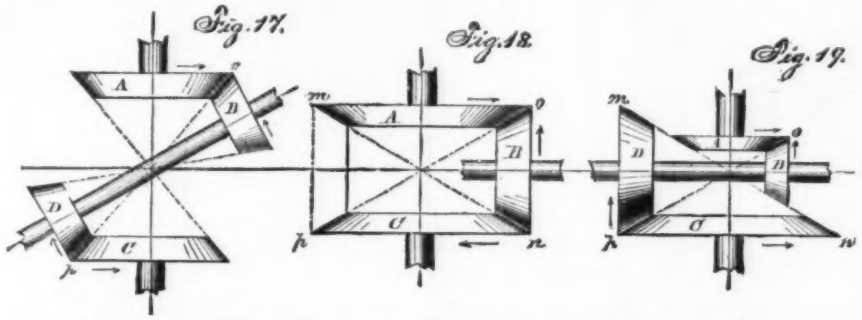


SKEW-BEVEL WHEELS.—BY PROF. C. W. MACCORD.

resembles those under consideration are scrutinized, it will be found that the pitch-surfaces are cylinders, tangent to each other at a single point only; and that the teeth, composed of helical instead of rectilinear elements, also touch each other only at one point.

It is, however, to be noted that although when the angle between the projections of the axes is sufficiently acute to avoid the interference of the teeth with each other, which will practically occur before those projections are exactly at right angles, the central pair of Fig. 12 may be employed, yet it is not desirable that they should be in any case; but, on the contrary, a better action will result if the frusta of the pitch-surfaces are removed as far as possible from the gorge planes. The reason is that the transverse obliquity of the teeth diminishes as the distance from the gorge circle increases. The measure of this obliquity, or skew, from which the name of the wheels is derived, at any point on the pitch-surface, is the angle between the generatrix, or rectilinear element, and the tangent to the hyperbolic outline, which intersect at that point.



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This obliquity, at any point, may be found as in Fig. 23, thus: Let $d\ k$, $d'\ k'$, be the projections of the generatrix when parallel to the plane of the paper in the side view, and p, p', those of the assumed point. The hyperbolic outline in the side view is evidently the section through the axis by a plane also parallel to the paper; and when p reaches a, the horizontal projection of the generatrix will be $a\ g$, and the vertical projection, $a'\ g'$, will be tangent to the curve at a'. Therefore, $a'\ g'$ is the vertical projection of the tangent to the hyperbole in the plane of the curve, of which the horizontal projection must consequently be $a\ k$; and the plane of this tangent and the element, $a\ g$, cuts the plane of the gorge in the line, $g\ k$, perpendicular to the paper in the side view, where it appears as the point, g'. The plane being inclined, the angle between the tangent to the hyperbola and the element is not seen in its true size; but by revolving the triangle, $k\ a\ g$, about $g\ k$, until it becomes horizontal, a' will go, in a circle whose center is g', to o', whose horizontal projection is o, and $g\ o\ k$ is the required angle or measure of the transverse obliquity at the given distance from the gorge plane.

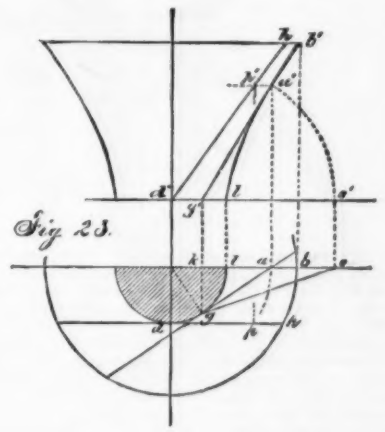
The advantage of selecting frusta as remote as may be from the gorge circles may also be seen from another point of view, thus: The distance between the axes is a constant quantity, and at an infinite distance from their common perpendicular the effect of their lateral separation would become imperceptible, which may be illustrated by supposing the axes of a pair of ordinary bevel-wheels to be slightly deranged in position, so as not quite to intersect; which would not sensibly impair the correctness of the action if the wheels were at a considerable distance from the point at which the axes ought to meet.

In was seen, in the discussion of the velocity ratio in the first article, that when the positions of the axes are given, the angle between their projections on a plane parallel to both is divided, in order to produce any assigned velocity ratio, exactly as though the axes intersected and the pitch surfaces were cones. Now it is to be noted that, if any two intersecting axes and the velocity ratio be given, it is always possible to satisfy those conditions by two pairs of cones, of which, however, the directional relations are opposite.

This is shown in Fig. 24: The lines, $x\ x$, $z\ z$, are drawn respectively parallel to the vertical and inclined axes, at distances from them inversely proportional to the angular velocities of the rotations about those axes; but while $x\ x$ is in both cases on the same side of the vertical axis, $z\ z$ is in one case on the one side, in the second case on the other, of the inclined axis. The conditions are purposely so taken in this instance that the cones at B, as well as those at A, are in external contact, their convex surfaces rolling together. The tangency will always, evidently, be of this nature if the axes intersect obliquely, and the intersection of $x\ x$ and $z\ z$ fall within the acute angle thus formed, as at A in this figure. And also, if the axes are perpendicular to each other, as will be seen by reference to Figs. 18 and 19. But when the intersection is oblique this will not always happen in the second construction—that is to say, if the common element of the pitch cones lies in the obtuse angle. Thus in Fig. 25 we have two cases: at A the cone with the vertical axis is hollow, the other one being tangent to it on its concave surface; while at B the common element is perpendicular to the vertical axis, and the cone has degenerated into a plane.

Now, recollecting that the cone is but the limiting form of the hyperboloid, it will be clear that each of the four modifications of bevel gearing represented in Figs. 24 and 25 will have its counterpart in skew-bevel gearing, as well as the one represented in Fig. 18, which has just been discussed; and, as in that case, we have only to suppose that the intersection of the axes is extended into a line of definite length, perpendicular to the paper, in order to be able to construct the corresponding hyperboloids in either instance. And it will be seen that when this is done, the result derived from Fig. 24, A, will be similar to that illustrated in Fig. 3, being, in fact, the arrangement most commonly met with in practice; while that derived from Fig. 25, A, will be like the combination shown in Fig. 5.

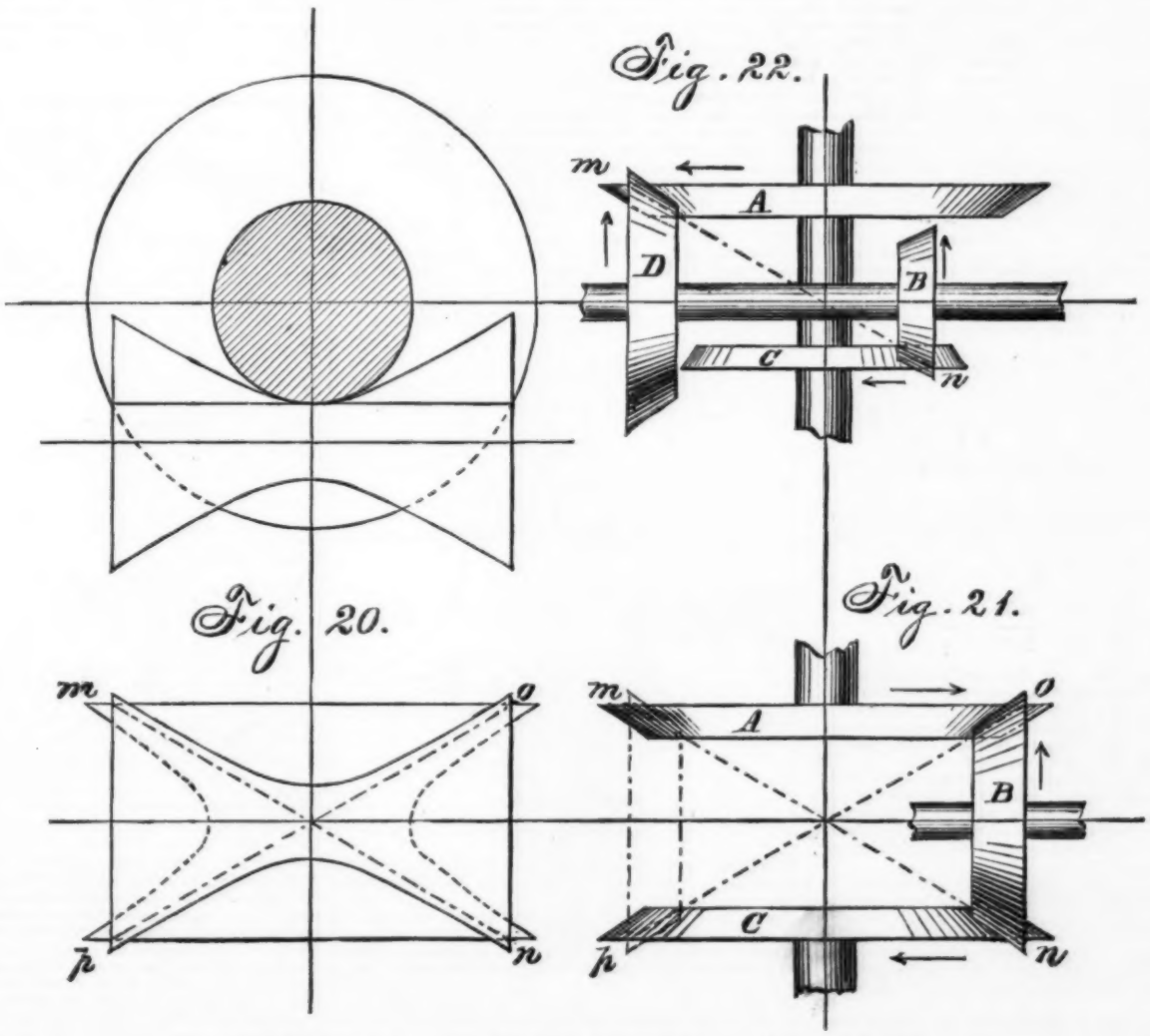
It will have been observed that the hyperboloid of revolution, although a surface of one nappe, is divided by the gorge plane into two parts, whose relations are very like those of the opposite nappes of the cone. In the two cases just alluded to, the common element of the tangent surfaces, be they cones or hyperboloids, may be indefinitely extended, forming the only line of tangency, and the parts of the surfaces on opposite sides of the intersection, or the common perpendicular, as the case may be, do not interfere with each other. In the cases illustrated in Figs. 18–22 inclusive, there are two lines of tangency, it is true, but these opposite parts of the surfaces do not intersect each other.



But in Fig. 24, B, it will be seen that if the attempt be made to extend the common element past the vertex, the opposite nappe of C will intersect D, and the opposite nappe of D will intersect C; but nevertheless these opposite nappes, if used, would roll together, the directional relation being the same as that between C and D.

The analogous case in skew-bevel gearing is shown in Fig. 26, and presents a rather curious appearance. The shaded frusta, C, D, correspond to the conical ones similarly lettered in Fig. 24, B; and they might be continued to the gorge planes without interference, but not beyond; as although the unshaded frusta, E, F, might be used instead of these, it will be seen that E would intersect D, and F would intersect C.

The relative positions of the axes and the velocity ratio, in this figure, are exactly the same as in Fig. 3, from which the wheels shown in Figs. 13 and 16 were constructed, the only



SKEW-BEVEL WHEELS.—BY PROF. C. W. MacCORD.

difference between the conditions in the two cases being in the directional relation; but in the construction of the pitch surfaces it is seen that the transverse obliquity in this case is very much greater than in the former; so that in order to use wheels to equal advantage in transmitting motion, it is necessary to select frusta at much greater distances from the gorge planes. And it is noticeable, too, that notwithstanding the lateral separation of the axes, it is impossible to carry the inclined shaft past the frustum, D, unless the latter be very near the gorge circle, although the vertical shaft may be extended either way to any distance without interfering with the inclined pitch surface. The teeth may be laid out in this case exactly as they were upon the pitch surfaces of Fig. 3; and the same may be said of the case in which the hyperboloids have two lines of contact, as in Fig. 20.

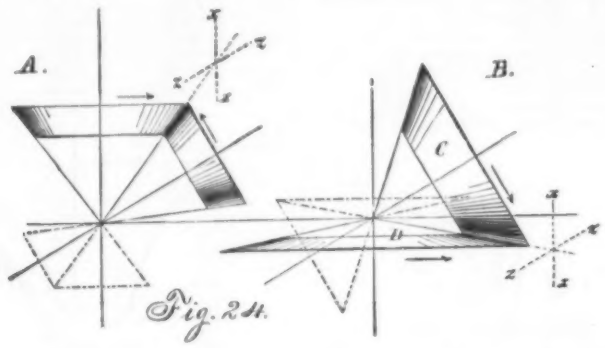


Fig. 24.

The analogue of Fig. 25, B, presents the remarkable feature that the pitch hyperboloids retain their limiting forms; the one remains a cone, the other a plane surface, as is shown in Fig. 27. Here X Y is the vertical axis, seen from above as the point, C; G H is the inclined axis, appearing in the top view, as F O. G R, whose horizontal projection is F B, is the generatrix, which intersects the inclined axis at G, and, by revolving about it, produces the cone, G R Z. As seen in the top view, the point, B, describes about the vertical axis the circle, I B T, seen in the other view, as K S; and the point, F, the circle, L F N, appearing in the side view as M P; that is to say, the hyperboloid is simply a circular disk with a round hole through it.

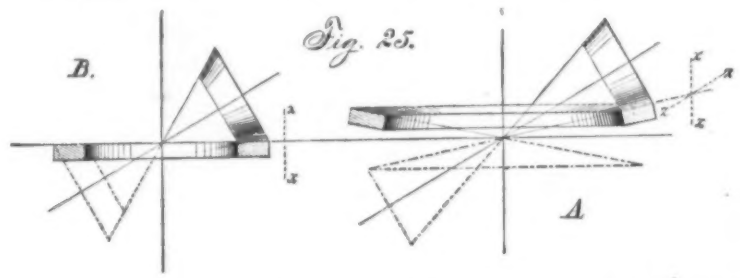


Fig. 25.

The determination of the velocity ratio in this case will be clearer if we consider the action of the outer circle of the disk, I B T, upon the base, R Z, of the cone. These circles have the common point, B, whose linear motion about X Y may be represented in magnitude and direction by B A, perpendicular to the radius, C B. This may be resolved into the components, B O, in the line of the common element of the cone and the plane hyperboloid, and B D perpendicular to it. Of these components the latter only is effective in transmitting rotation, B O being the component of sliding in the direction of the line of tangency; and since B D is perpendicular to the radius, E R, of the cone's base at its extremity, it is tangent to the circumference at B, and represents the linear motion of that point around the inclined axis. Now let

$$v = \text{Ang. vel. about vertical axis},$$
$$v' = \text{Ang. vel. about inclined axis},$$

then, since $\text{Ang. vel.} = \frac{\text{lin. vel.}}{\text{radius}}$, we shall have

$$\left.\begin{aligned} v &= \frac{BA}{BC} \\ v' &= \frac{BD}{RE} \end{aligned}\right\} \therefore \frac{v}{v'} = \frac{BA}{BC} \times \frac{RE}{BD} = \frac{BA}{BD} \times \frac{RE}{BC}$$

But the triangles, A B D, B C F, are similar, their homologous sides being perpendicular to each other, whence $\frac{BA}{BD} = \frac{BC}{BF}$, $= \frac{BC}{RG}$, since B F = R G.

Substituting, we have $\frac{v}{v'} = \frac{BC}{RG} \times \frac{RE}{BC} = \frac{RE}{RG}$.

As in the preceding cases, then, the velocity ratio depends wholly upon the projections of the axes and common element upon a plane parallel to all three, and the singular circumstance results that the angular velocity of the cone is not affected by the lateral separation of the axes or the change in the diameter of the disk which drives it.

Nor are the peculiarities of this case confined to the pitch surfaces. The common normal must be perpendicular to the plane hyperboloid, and therefore parallel to its axis, so that one normal cone becomes a cylinder. But this normal intersects the axis of the conical hyperboloid, generating for it a true normal cone as before.

Again, it will be seen that in applying the method used in the preceding cases to the construction of the teeth, the describing surface also will be a cone. This would move in pure rolling contact with the conical hyperboloid, and the tooth surfaces generated, being composed of elements, all of which must pass through the vertex of the pitch surface, would also be conical, and identical with those of an ordinary bevel wheel.

But this describing cone would not move in perfect rolling contact with the plane hyperboloid. An idea of the nature of the action, and of the surface which would be generated, may be formed by considering the conical hyperboloid shown in Fig. 27 to be a describing surface; supposing the plane disk to remain stationary, let the cone rotate about its own axis, G H, the linear velocity of any point in its base, due to such rotation only, being represented by B D as before. Let G Z, whose horizontal projection is F W, be taken as the describing line of the tooth-surface. Then the motion of the point, W, due to the axial rotation of the cone, will be represented by W Y, perpendicular to F B, and equal to B D. But the whole cone now revolves around the vertical axis, at a rate such that the vertical velocity of the point, B, will be represented by A B. This orbital motion of W will be represented by a line, W Q, perpendicular to C W, whose length is such that C B : C W :: B A : W Q; graphically determined, therefore, by making the angle, W C Q, equal to the angle, B C A. Completing the parallelogram, Y W Q U, we have as the resultant motion in space of the point, W, the line, W U, parallel to the paper in this view, and passing through Z in the other view. The motion of the point, F, is evidently in the direction B F, seen in the other view as R G; the motion of the line, F W, or G Z, therefore, is at this instant one of sliding on the two lines, B F, W U, which are not in the same place.

The generated surface, therefore, will be a warped one. But the same describing line is at the same time generating a conical surface for the tooth of the other hyperboloid; the conical and the warped tooth-surfaces must, therefore, have a common rectilinear element. This being the case, they will not be tangent to each other, but will intersect. For in order to be tangent, they must have at every point of the common element a common tangent plane: and the plane tangent to the conical surface at one point is tangent all along the rectilinear element passing through that point, while it is tangent to the warped surface at only one point; and the planes tangent to the latter at other points of the common element, while they contain that element, will not coincide with the first plane, and will consequently intersect the conical surface.

It follows, then, that in this singular case the construction of teeth which shall work in line contact is impossible.

But it does not follow that it is wholly impracticable to furnish these surfaces with teeth by which the motion may be made positive, and the velocity ratio maintained with perfect constancy: the mode of doing which it will suffice merely to indicate.

If we suppose the cone in Fig. 27 to be made up of thin transverse laminæ, and these to be twisted upon each other as in the construction of Hooke's gearing, it is clear that the rectilinear element will be changed into a conical helix. Let the plane hyperboloid be supposed to consist of as many concentric rings as there are laminæ in the cone; each of these will be driven round by the supposed rotation or twisting of its corresponding laminæ, distorting the line, F B, on the disk into a curve of a spiral form. The plane disk and the cone will still be tangent along the right line, F B; and it will now be possible to form teeth which shall begin and end contact on that line, their outlines having the general direction of the spiral and the helix respectively. The amount of the twist given to the laminæ of the cone being made, in the length of the frustum employed, equal to or a little greater than the pitch, there will always be one point of contact between the teeth, which will travel along the line, F B, as the rotation progresses, and the action will be smooth and uninterrupted.

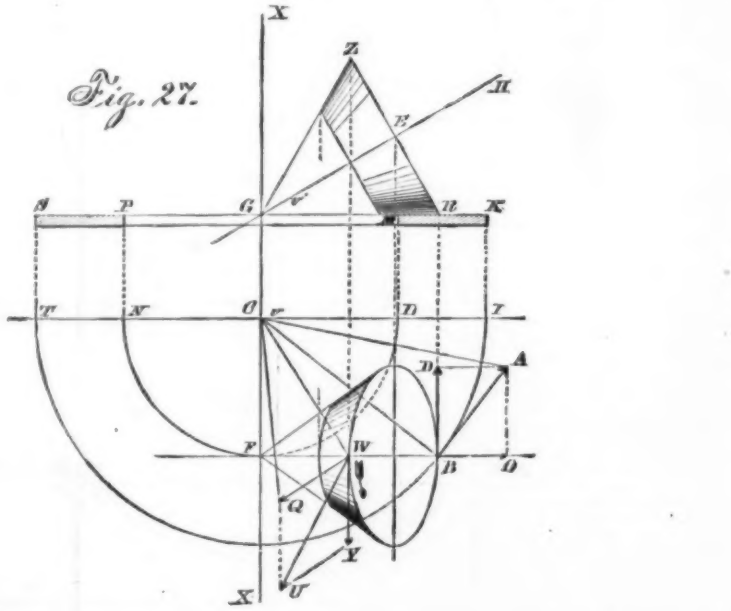


Fig. 27.

And it may be worth while to point out that a similar process may be applied to any pair of tangent hyperboloids, the twisting of the laminæ upon each other changing the rectilinear elements, which ultimately represent the teeth, into hyperboloidal helices, while the pitch surfaces touch along a right line as before.

Nor would the actual execution of such Twisted Skew-bevel wheels appear to be so formidable a task as one might think at first glance. If a milling cutter be fed along in the direction of a rectilinear element of the pitch surface, while at the same time the blank by proper mechanism is uniformly rotated on its axis, the proper direction will be given to the cut; the only line upon the tooth which it is essential to preserve is the helix on the pitch surface, since there is neither acting face nor flank. The former, or projecting part of the tooth, may therefore be of almost any form, and the form of the space within the pitch surface is equally immaterial, so that it clears the projecting part of the tooth of the other wheel. And the action of such teeth, though they have of course only a point of contact, will, as in Hooke's gearing, of which, indeed, it is only a special but hitherto neglected if not an overlooked application, be smooth and uniform, since it can be attended with no more sliding than that existing between the pitch surfaces themselves.

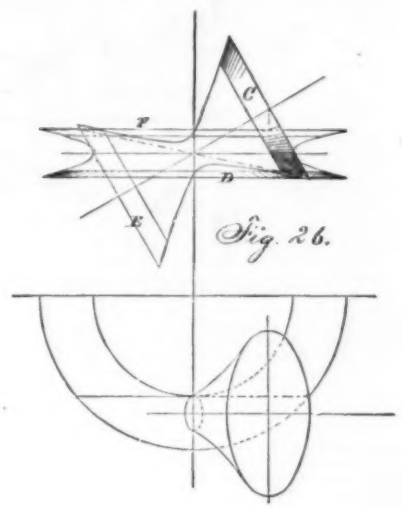


Fig. 26.

100-HORSE POWER FRENCH BEAM ENGINE.

THE engine which we illustrate on next page was exhibited in the French machinery hall, in Class 54, driving part of the transmission; its nominal power is 100 horses, but it develops an indicated horse power of 350 horses. The engine is surmounted by a platform and gallery in cast iron surrounding the beam, which are supported by ten cast iron columns, four of which in the center carry the frame, to which the entablature is fixed, on which the plummer-blocks of the beam are mounted. The beam, which is 24 ft. 7 in. long, weighs about 10 tons. The diameter of the fly-wheel is 23 ft., the form of the rim rectangular, and the weight about 15 tons. The shaft on which it is keyed, as well as the crank, which is nearly 3 ft. 7 in. in length, are made of wrought iron. The connecting rod, which is worthy of notice for its symmetry of form and the rigidity with which it works, is made of cast iron. The two cylinders, which work

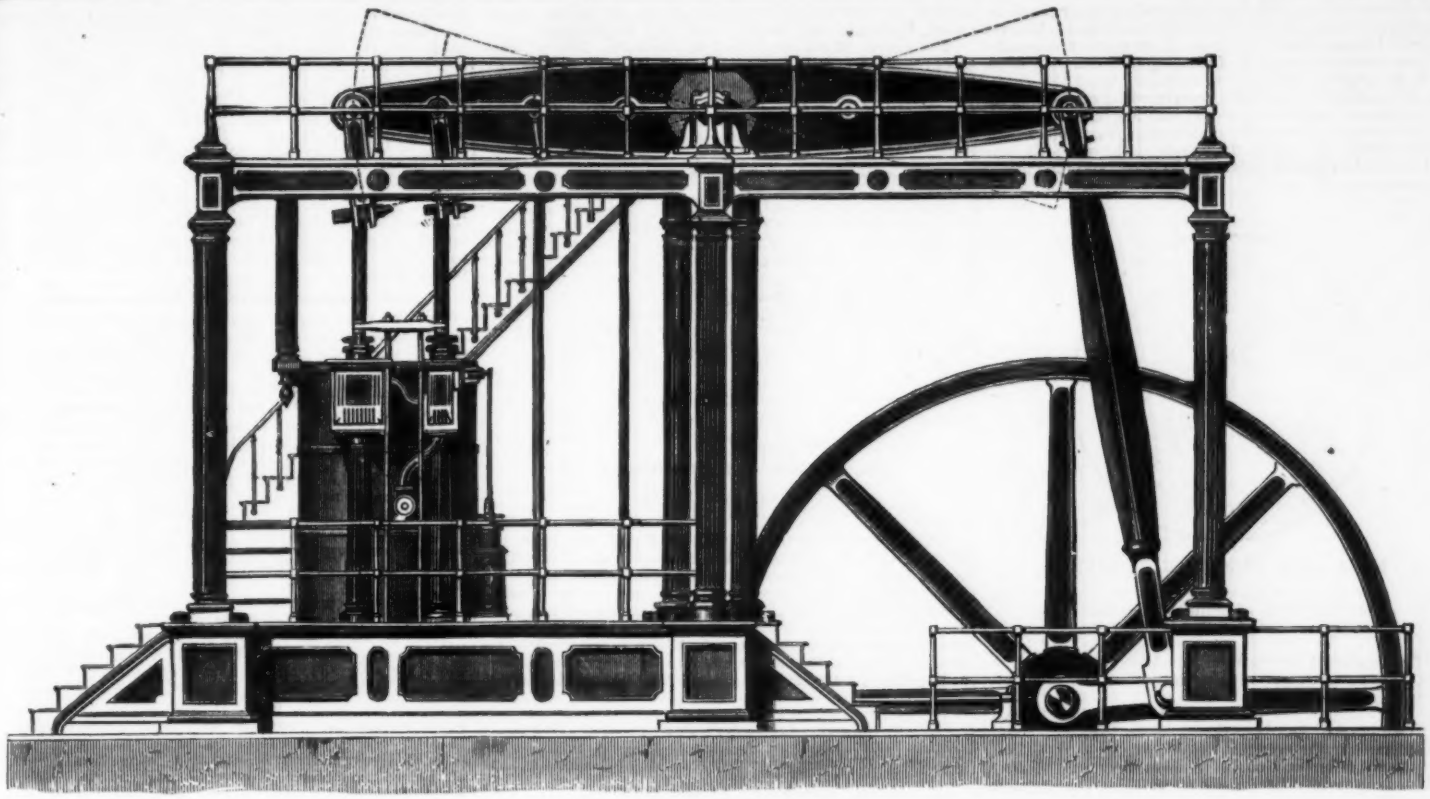


FIG 1.—100-HORSE POWER FRENCH BEAM ENGINE.

on the Woolf system, are steam jacketed, the height of the outside casing being about 8 ft. 6 in., and are lagged with oak and copper bands lined with cowhair felt, to prevent condensation. The governor is placed between the four columns which support the beam, and transmits its movement to the patent valve gear, acting directly on the slide or expansion valve of the small cylinder without the use of a throttle valve. The mechanism of the expansion gear is shown in the detail engraving, where A is a cylinder in brass; B, an orifice between the cylinder and its jacket; C, pipe communicating between the jacket and condenser; D, pipe conducting to the hot-well; E, piston of the cylinder A without packing; E^1, rectangular orifices, four in number, equal and symmetrical, placed opposite the ports of a circular valve, carried by a rod passing through the piston rod; H is a guide attached to the cross-bar, K, allowing a vertical motion to the socket, I, which is pierced by two helical grooves, and fixed to the rod of the circular valve by a pin or cotter; F is a rod which supports the socket, I, and is articulated with the lever of the coupling on the governor. A collar or ring of bronze is fixed to the tappet cam, M. M is a grooved cam actuating the expansion valve, cottered on the spindle, N; N_1 is a vertical spindle carrying the grooved cam, and receiving its motion from the toothed gear mounted on the horizontal shaft working the steam and exhaust valves; O is a tappet pressing on the cam and put in motion by the variable projection of the boss; P is a lever articulated at *p*, carrying the stop or tappet, O, and transmitting motion to the expansion valve through the rod, Q; R is the rod of the counterweight for the back motion of the valve; S is a cast iron column for supporting the valve gear. The pipe, *c*, which leads to the condenser, is fitted with a cock. T is an expansion valve; U is the valve of the small steam cylinder; V is the steam chest of the small steam cylinder; X is the starting valve of the engine; Y is the steam pipe. The steam is admitted through the jacketing into the valve chest by means of the starting valve. The expansion valve, of a circular form, is kept in contact with the interior surface of the valve chest by the pressure of the steam. The motion is governed by the rod attached to the lever, P, which keeps the stop, O, in contact with the embossed cam, which in moving causes the lever, P, to describe the arc of a circle, varying in length according to the development of the boss in contact with the stop. The cam is driven by toothed gear on the spindle which governs the valves, and the rectilinear movement of the cam, ascending or descending, is determined by the movement of the piston, E, which is connected with it by the ring, L, the vertical connecting rods, and the cross-bar, K. The piston, with its rod, cross-bar, connecting rods, ring, and embossed cam, represents a certain weight, which tends to lower it when the relative position between the embossed cam and the stop or tappet undergoes a change, but a certain amount of counter-pressure is met with in the jacket of the cylinder on account of its being in communication with the condenser, or at least with the pipe leading to it. On the other hand, owing to the pressure established underneath the piston, or rather to the base of the cylinder being in connection with the hot well of the condenser, we see that the head of the cylinder communicates with the counter-pressure in the jacket by the constant opening, B, while at the same time it is subjected to the influence of the pressure underneath the piston in proportion to the size of the openings, E^1, which are variable. A certain counter-pressure is therefore established in the top of the cylinder, whose value is dependent on the relation between the pressure below the piston and that in the jacket, and also between the sections of the constant opening, B, and the variable openings, E^1.

To produce an equilibrium, it is necessary for the counter-pressure above the piston to be equal to the pressure below it, *plus* the weight of the moving parts, and this is obtained by suitably regulating the sectional area of the orifices, E^1. When the speed of the engine varies, the form of the governor is altered, and the motion of its clutch is transmitted through the rod, F, to the socket, I, and the latter is raised or lowered according to the variation of speed. This vertical motion is transformed into a rotary movement of the circular valve of the piston by the action of the helical grooves drilled in the socket, I, on the cotter at the base of the rod, and instantly effects an alteration of the proportion between the areas of the openings, E^1 and B, disturbs the equilibrium, and produces a vertical motion of the whole of the movable parts. If the speed be accelerated, the governor clutch is raised, the grooved socket descends, and the play of the cotter slightly opens the orifices, E^1. The result is that the counter-pressure above the piston is decreased, the whole movable parts descend by gravity, the embossed cam offers to the stop a section whose projections are less pronounced, and the admission of the steam is reduced. Inversely, if the governor is required to accelerate the speed of the engine, *i.e.*, if it has sunk a little, the play of the socket, I, on the cotter slightly closes the orifices, E^1, the counter-pressure becomes greater than the surrounding pressure, and the movable parts, acted on by a contrary influence, are raised. These different motions of the piston and embossed cam are very smooth, being the result of dispositions which allow the suppression of any intermediate parts. The resistance is reduced to the friction of the cotter, which governs the motion of the embossed cam and of the tappet, and the action is so sensitive that any alteration of speed, even if imperceptible, produces an immediate effect on the inlet of the steam.

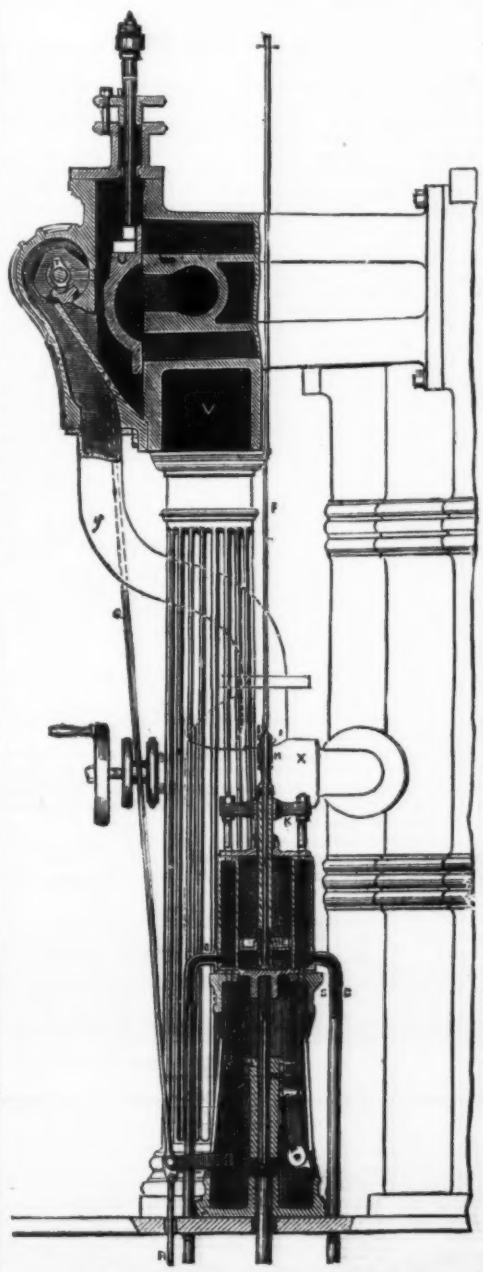


FIG. 2.—FRENCH BEAM ENGINE.

The valve gear of this engine was without doubt the widest departure from the numerous modifications of the Corliss valve in the Exhibition, and for the simplicity of action was alone worth inspection; but, in addition to this, the engine reflects great credit on its constructors for symmetry of design, high-class workmanship, and excellent performance. The condenser and air pump are placed at the side of the steam cylinders below the bed plate, and are worked direct from the beam, as well as the feed pump for the boilers.

According to the statements of the exhibitors, the performances of these engines are most satisfactory, and the result of numerous trials gives a consumption of 1 kilog. of fuel per horse-power per hour in lifting water, notably at the water works of Nantes, Roubaix and Courcoing, Angers, Reims, etc.; or a consumption of 0·900 kilog. about per indicated horse-power. Several engines delivered by them for private industries consume on an average only 0·812 kilog. of coal per hour and per indicated horse-power. E. Windsor et Fils, engineers, Rouen.—*The Engineer.*

THE THEORY OF THE GROOVES IN MILLSTONES.

CERTAIN laws govern the action of the furrows in millstones, and with these every rational miller should be acquainted, inasmuch as the same are very easily comprehended.

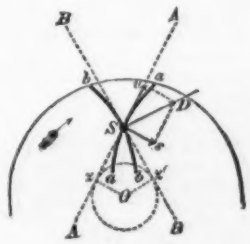


FIG. 1.

In Fig. 1 let *a a* represent a groove in the stationary stone, and *b b* a groove in the stone that revolves in the direction of the arrow. If, in the point, S, a tangent is drawn to each of these curves, these two tangents will form the angle of intersection.

A grain of corn, wheat, etc., that is at the point, S, receives a certain pressure in the direction of S D, by the revolving stone; and by means of the parallelogram of forces, these pressures can be divided into two forces, *i.e.*, S *s*, which cuts the grain, and S *v*, which forces the product, or flour, outward. These two forces are in a certain relation to the

angle of intersection, which is so that when the angle of intersection increases, the cutting power will decrease, but, *vice versa*, will increase when the angle of intersection decreases From the above statement the following rules can be evolved.

1. If the angle of intersection increases from the center to the circumference, the cutting power will decrease, and the force for throwing out the product will increase.

2. If the angle of intersection decreases from the circumference toward the center, the power of throwing the product toward the circumference will decrease, and the cutting power increase.

FIG. 2.—OLD CIRCULAR GROOVE.

a=circle of centers.
b=four-fifths of radius of the stone
c=four-fifths of radius of the stone.

3. If the angle of intersection does not increase nor decrease, the powers will always remain in the same proportion.

The following law (by Wiebe) should also be kept in memory: Two curved grooves, that operate together, should never intersect in the points.

Very many different kinds of grooves have been devised, which can be divided into two general classes, *i.e.*, straight and curved.

The curved grooves are subdivided into circular and spiral grooves.

The grooves can also be divided into different classes in regard to the angle of intersection, *i.e.*:

1. Grooves having the intersecting angle increasing from the center toward the circumference. Such are the old circular grooves.

2. Grooves having the angle of intersection not variable in regard to the circumference. Such are the Wiebe, the logarithmic, spiral, and most all spiral grooves.

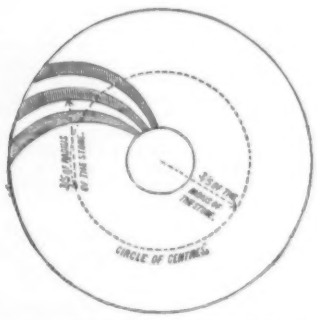


FIG. 3.—IMPROVED CIRCULAR GROOVE.

a=circle of centers.
b=three-fifths of radius of the stone.
c=three-fifths of radius of the stone.

3. Grooves having the angle of intersection decreasing from the center toward the circumference. Such are the new circular groove and the Evans groove.

The construction of the different curves for the grooves is as follows:

1. The old circular groove (see Fig. 2). The diameter of the stone and of the center of the same (the eye) are laid down. A circle is then struck from the center of the stone, having a radius equal to 4-5ths of the radius of the stone. If a point of this inner circle is taken as center, and with the radius of this inner circle, a circle from the circumference of the stone to its center is constructed, this gives us the old circular groove.

Instead of making the radius of the inner circle equal to 4-5ths of the radius of the stone, $\frac{7}{8}$ can be taken as well. For instance, in a stone of 4 feet diameter and 10 inches diameter of the center (eye), if the radius of the inner circle is 4-5ths of the radius of the stone, the angle of intersection is at the eye 15°, and at the circumference 77°; but if the radius of the inner circle is equal to $\frac{7}{8}$ of the radius of the stone, the angles will be 14° and 69° respectively.

For a stone of 4½ to 5 feet in diameter, 108 of these grooves are generally applied, 54 of which extend from the circumference to the eye, and 54 only 2-3ds of this distance.

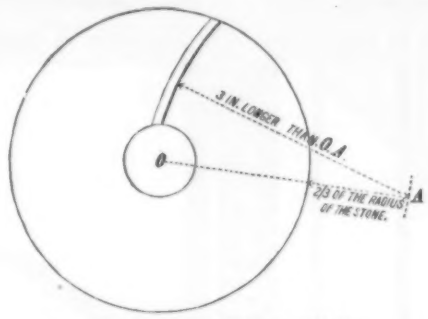


FIG. 4.—NEW CIRCULAR GROOVE.

a=three inches larger than OA.
b=two-thirds of the radius of the stone.

2. The improved circular groove (see Fig. 3). The curvature of the groove is increased. The circumference of the stone and the eye are laid down as in the preceding case. An inner circle is also constructed, but now with a radius equal to only 3-5ths of the radius of the stone. The curves are then constructed with the radius of the inner circle, and their centers must in every case be in this inner circle. Of these grooves not so many are cut into the stone as in the preceding class; but we must always bear in mind that for

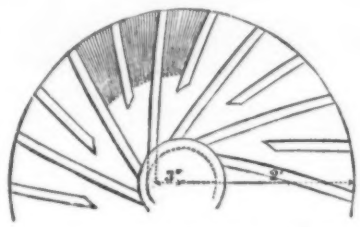


FIG. 5.—NEW CIRCULAR GROOVE.

grinding wheat the spaces between the grooves must never be more than 2 inches wide. In a stone of 4 feet diameter, of 10 inches diameter of the eye, the angle of intersection will be at the eye 38°, and the circumference 110°.

3. The new circular groove (see Fig. 4). The elongation of the preceding grooves would have passed through the center, and this caused the angles to increase toward the circumference. In the new circular groove the curves never pass through the center, and their radius is much larger than the radius of the stone.

The circumference of the eye and the stone are laid down as before, and a line drawn from the center of the stone to the circumference. This is elongated and 2-3 of the radius of the stone added, so that the length of this line will be equal to $1\frac{2}{3}$ radius of the stone.

To this line 3 inches are added, and then a circle constructed having its center at the end of the line, and a radius equal to the length of the line plus 3 inches. The width of the groove is then added to this radius, and a curve parallel to the first constructed. A template can then be made, and the other grooves of the stone cut according to the template. Taking the same stone, having a diameter of 4 feet, and 10 inches diameter of the eye, we have an angle of intersection equal to 47° at the eye, 42° at the circumference, and 37° at a distance from the circumference equal to half the radius of the eye. From this it is apparent that the angle slowly decreases until near the circumference, and then increases some.

Another construction is shown in Fig. 5. A radius is drawn, lengthened beyond the circumference until it is equal to the diameter; the end of this line is taken as a center, then the line is lengthened 3 inches, and with the radius so obtained a circle is struck, and the curve cut according to this circle.

THE CONSTRUCTION OF THE SPIRAL GROOVES.

The spiral grooves are curves constructed on the line of the logarithmic spiral. The logarithmic spiral cannot be constructed with a pair of dividers or similar instruments. The construction of this line is governed by the laws of higher mathematics (see Fig. 6).

The two lines, O E and O B, are laid down perpendicular to each other. The eye or center is then constructed with the radius O 1, and the quadrant, 7 E, is constructed with the radius O 7. The line, 1 E, is halved at 4, and the part 1 to 4 is divided into 6 equal parts, numbered 1, 2, 3, etc. Half of the desired angle of intersection O 7 C is then constructed at the point 7; from the point O a perpendicular, O VII, is erected on to the line 7 C. From the 6, 5, 4, 3, 2, and 1, lines are drawn parallel to O VII, and by these means certain points, I, II, III, IV, V, VI, and VII, obtained on the line O VII.

Taking the point O as a center, circles are constructed from these points on the line O VII.

From E, a tangent is drawn to the circle O VII. This will intersect at *a*, with a circle drawn from the center O, and lying between 6 and 7. From *a*, a tangent is drawn to the circle O VI, and where, at point, L, this tangent intersects with the circle O 6, is a point of the logarithmic spiral. From the point *b*, where this same tangent and the circle drawn between 5 and 6 from the center O intersect, a tangent is drawn to the circle O V, and at A, where this tangent and the circle O 5 intersect, is a second point of the logarithmic spiral.

In the same manner more points of this spiral can be obtained, and if these points S P I R A L E are connected, we have the desired logarithmic spiral.—*Lehrbuch der Mülerei von Gustav Pappenheim.*

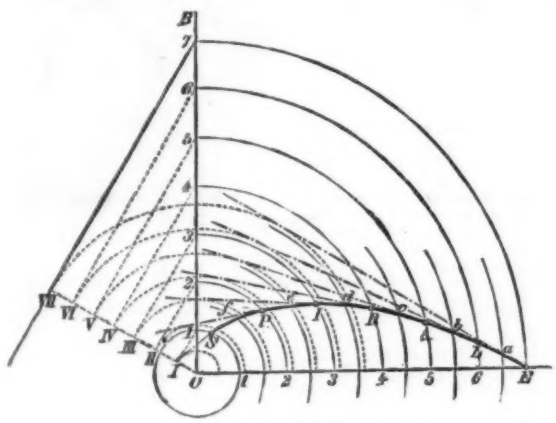
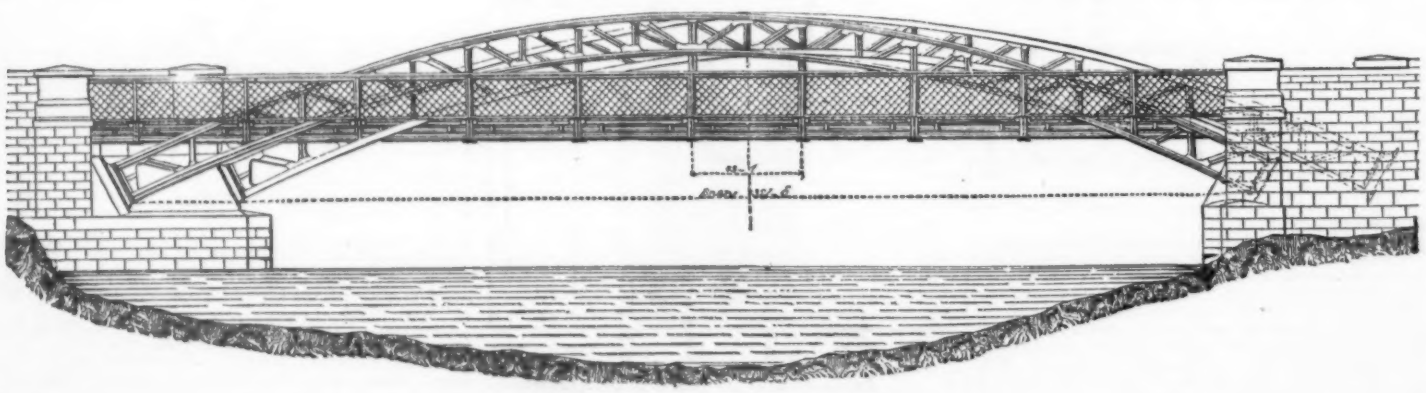


FIG. 6.—LOGARITHMIC SPIRAL.

THE DERWENT BRIDGE.

THE Great Northern Railway Company not long since completed their new railway across the Derbyshire coalfields. The line leaves Nottingham in a north-westerly direction, crosses the Erewash Valley line of the Midland Railway, near Ilkeston, and then trends to the south-west to the town of Derby. The new railway traverses the town nearly from north to south, and besides numerous bridges for the street crossings, it includes two important structures, one carrying the line over the river Derwent, and a handsome cast-iron arched bridge over Friargate. The first of these two bridges —that over the Derwent—we illustrate by a general elevation of the structure. It will be seen that the structure is an arched skew bridge. The arch projects at the crown over the platform, and abuts on cast-iron plates at the springings. Thus the platform is partly suspended from the arch and partly rests on it. The bridge has a clear span of 132 ft. and a width of 28 ft. 6 in. between centers of ribs. It carries two lines of railway, and has an overhanging footway on one side, 7 ft. 7 in. in width between the center of the main rib and the handrailing. Each rib is composed of four members of an H built up section, between each pair of which the verticals and diagonals forming the bracing of the



DERWENT RIVER BRIDGE.

arch are placed, both the latter being also of H section. Every alternate vertical member is continued to the cross girders, widening toward them and forming with them a broad U frame, as seen in Fig. 3. The rigidity of these U frames prevents the arch from collapsing laterally under a compressive strain. The cross girders are 2 ft. 2 in. deep, and are placed 13 ft. apart, and carry longitudinal rail bearers 1 ft. 8 in. deep, one under each rail. Over the iron rail bearers are laid 4 in. packing pieces, to which 4 in. cross planking is nailed. Upon the planking are 12 in. by 6 in. longitudinal timber sleepers carrying the rails, and bolted through to the longitudinal iron bearers. There are three lines of iron handrailings, one on either side of the railway, and the third on the outside of the foothway, all of plain lattice pattern. The bridge has been calculated for a moving load of 1½ tons per foot lineal of line equally distributed, and also for concentrated loads, as in accordance with the heaviest engines on the line. The strain on the iron does not exceed 4 tons per square inch in any part of the structure. The strain in the arch due to variations of temperature have been duly provided for.

The general street bridges to which we have referred were made by Messrs. Handyside & Co. (whose works are situated in the neighborhood of the bridge we have just described) for the contractors of the railway. For the Derwent Bridge and that over Friargate, however, this firm contracted directly with the Great Northern Railway Company. The river bed at the site is not well adapted for pier supports, and either screw piles or cylinders would besides have interfered with the navigation. The railway approaches have been strongly constructed as abutments, and the design affords a strong and substantial looking bridge at a moderate weight. The bridge was put together and tried at Messrs. Handyside's works, and was erected in position by them over the river. The work was completed in the early part of last year and was tested by three locomotives of 72 tons each on each line, in all six locomotives, with a total load of 432 tons. There are 155 tons of wrought iron and 11 tons of cast iron in the structure. Mr. Samuel Abbott, Memb. Inst. C.E., the resident engineer for the Great Northern Railway Company's Derbyshire lines, had the general control of the works under the direction of Mr. Richard Johnson, engineer-in chief to the Great Northern Railway Company.—*Engineering.*

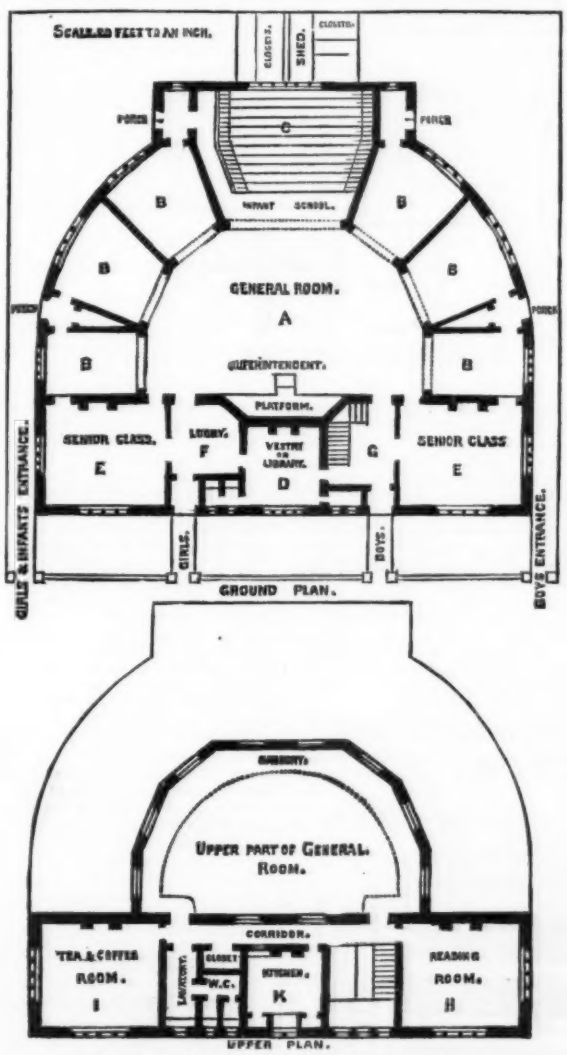
SUNDAY-SCHOOL BUILDINGS.

A SERIES of articles on the above subject has recently appeared in the *Church Sunday-School Magazine*, written by Mr. C. G. Maylard, A.R.I.B.A., which offer some suggestions for the consideration of builders of Sunday-schools. It will at once be admitted that the present buildings which answer this purpose in our towns are deplorably defective in planning, uncomfortable, and in most cases quite inadequate for the purposes of Sunday-school teaching. In the majority of instances they are hired rooms in unhealthy localities, low, ill-lighted, and unventilated. Mr. Maylard, who has given, we believe, much attention to the wants of Sunday-school building, points out the value of separate class-rooms for the use of scholars whom it is desired to attach to the church. He says justly, "in every case, whether a large or small school, there ought to be one general room, with the necessary class-rooms in number according to the size of the parish. It is of paramount importance that these adjuncts to the school should be as numerous as possible, consistently with the extent of the population, and the smallest school should not have less than two."

It is doubtless, as the author points out, the policy of the clergy to provide separate rooms to prevent the elder members leaving at a time when they ought to become attached to the church. Advanced scholars do not care to mix with younger children, but if other rooms were provided they could meet as Bible classes. These rooms would also be available for other uses, such as instruction for confirmation, servants' classes, reading, etc. If, further, these separate rooms could be made capable of being thrown into one general room, an additional advantage would be insured, as such a large room could be turned to various purposes for parochial meetings or entertainments. The author shows first how a school for a small parish may be planned. He proposes a general schoolroom 40 ft. by 30 ft., with two class-rooms at one end, each 18 ft. by14 ft., opening into the general room by folding or sliding doors, each class room to have its own entrance. At the other end of school-room is shown the main porch entrance at one corner, a recess for superintendent's desk in middle, and a small class-room with separate entrance at the other corner. Such a general schoolroom will accommodate at the usual allowance of 8 ft. superficial to each scholar, 200 children, and the class-rooms 20 for Bible classes, or 40 infants as a gallery. The room could easily be improvised into a church or used for mission services by making the recess a chancel, and the small class-room at side a vestry, and by removing the doors of the two class-rooms at the other end; in this way 300 people might be seated. It is pointed out that the room may be divided by curtains.

Another plan on a similar principle, but with separate rooms for the boys and girls, is given. The arrangement is that of an inverted T, the vertical part being the boys' and the horizontal part the girls' school. At the end of boys' school two class-rooms are shown, 14 ft. by 14 ft. each, opening into it, and with separate entrances; also two other class-rooms, each 22 ft. by 14 ft., in the angles of large rooms, available for either school. The large schoolrooms are 40 ft. by 30 ft. for the boys, and 56 ft. by 30 ft. for the girls, the two being capable of being thrown into one by the removal of a partition. The class-rooms are also arranged to be thrown together for mission services, etc. The school is capable of accommodating from 500 to 600.

Mr. Maylard next proceeds to show the advantages of the "radiating" or American system—a plan which has partially at least been introduced into this country. A combination of the rectangular and radiating principles is shown by a plan of a school at Wandsworth, Mr. J. Weir, architect, designed for the Wesleyan Sunday-school Union. The schoolroom is 51 ft. by 34 ft.; at one end are four class-rooms, arranged round a segment—in plan the arrangement looks like an arch with four voussoirs, segmental in its inner curve, and with straight extrados. At the other end is a shallow recess and platform, which might be used as a chancel. But the author advocates a more thorough carrying out of the radiating plan, and furnishes two plans to illustrate his remarks. One of these represents a simple semicircular building, the central space being the general school, 30 ft. radius from the superintendent's desk, which forms the center of chord line or diameter, a platform recess being behind. Six class-rooms, each 22 ft. by 18 ft., are arranged round the outer line of this semicircular space, with radiating division walls, and separate entrances and wide openings with folding doors toward the schoolroom, so that every scholar can see the superintendent, while each class-room is equidistantly placed from the desk. Such a school would seat 180 children in eighteen classes, while, with the class-rooms, it would accommodate nearly 600. A front or straight range of building contains two Bible class-rooms for adults, committee-rooms, stairs, and lavatories. It is easy to see that this plan is well adapted for a large parish, lends itself admirably to parochial or other meetings by removing the folding doors and erecting galleries over some of the class-rooms—an arrangement that would enable 1,000 people to be seated.



PLANS FOR SCHOOL ROOMS.

We are indebted to the author for the use of the accompanying plan, which explains this arrangement more fully. As will be seen, it contains a general room with radiating class-rooms at the sides, and an infants' class-room, with separate entrances. We quote the author's description: "On the ground floor is a central room, A, 40 ft. by 20 ft., for 150 scholars; six radiating class-rooms, B, for 156 scholars, and an infants' class-room, C, for 85 scholars, all with separate accesses, and all available for use as one large room to seat 500 people. The position of the desk of the superintendent is such that from it he can see every scholar in all these rooms, and the same would be the case when used for church services. A large arched recess is at the back of his desk, with a platform for speakers on occasions of parochial meetings. A vestry or library, D, is arranged at the back of the platform, with lavatory, water-closet, and book cupboard. Right and left of this room are entrances for senior boys and girls respectively, with a class-room, E, for each, to hold 36. The total number of scholars thus provided for is 463." F is a large waiting lobby for use of those who get books, while C is a lobby and stairs leading to a reading-room, tea and coffee room, and kitchen, in connection in center. A gallery round the general room could be readily constructed, available for parents on prize distributions, and it is also pointed out that the two senior class-rooms are sufficiently high to obtain a mezzanine story for caretaker's rooms over lobby and vestry. The general room would be lighted by a series of windows above the openings of class-rooms, the latter being kept low. From this plan it is clear the space is occupied in an economical manner, and that the system adapts itself to square sites. On the rectangular plan of building a large part of such a site becomes necessarily occupied by projecting class-rooms, and the land is more cut up. Referring to cost, the author bases his calculations upon the London market, and allows 6d. per foot cube. The small rectangular plan we first described would at this rate cost £1,150, or a little over £4 a child; the larger plan for 550 scholars would cost about £2,350, and the large radiating school for 700 scholars would cost about £3,000; the one we illustrate about £2,500, these sums including external conveniences and boundary walls, but no fittings.

Various details and sanitary hints are given by the author in his concluding paper, to which it is here hardly necessary to refer. The selection of a sunny aspect for the windows is, of course, desirable; heating is best effected by hot water or air, with open fireplace in the class-rooms if necessary. Air-chambered grates, drawing their air-supply from the outside, are recommended, the heated air escaping through a grating at the top, capable of being regulated. As regards the ventilation, separate ventilating flues in connection with the smoke-flues are advocated, openings for the exit of vitiated air being made near the ceiling, having a Sherringham, Boyle, or Arnott's valve. Draught is maintained by gas-jets placed just above the valves in the flues, and lighted by an opening with glazed door. Sun-burners with shafts are also recommended for flat ceiled schools. The fresh air is proposed to be introduced behind a wood dado, having a space of about 2 in., with movable hinged flaps for the admission of air. With regard to the class-room doors, the author prefers those which slide up from the floor into the wall, hung at the sides like sashes, to folding doors; in this case the general school would have to be top-lighted or arranged as a domical lantern. Mr Maylard's suggestions are sensible, while the system of arrangement he advocates is strictly scientific.—*Building News.*

ELECTROMOTIVE FORCE—RESISTANCE AND CURRENT.

BY J. T. SPRAGUE.

THE purpose of the present article is to develop the interrelations of the three fundamental expressions and units of dynamic (or moving) electricity, to give them somewhat more definiteness than is usual in the ordinary text-books, and to do this mainly by showing what physical realities underlie the terms and formulæ used by electricians.

Of course, the text from which these practical lessons are to be drawn is the well-known formula of Ohm $\frac{E}{R} = C$. The current is proportional to the electromotive force divided by the resistance; or, employing the received units of the British Association system of measurement, $\frac{E \text{ volt}}{R \text{ ohm}} = C$ weber. The very first point to be considered is whether these symbols have any reality behind them. Are they mere mathematical abstractions, simple tools of thought, or are they concrete realities? Now, this is really a very serious question, because these scientific formulæ are now so extensively employed and so completely relied upon that they acquire a kind of imaginative actuality, just as the creations of popular writers do. Thus Scott's "Ivanhoe" is possessed, to most readers, of as distinct a personality as Richard Cœur de Lion, and probably the personality of the latter, notwithstanding the fact that he had an actual living existence, is built much more strongly upon Scott's "Ivanhoe" and "Talisman," than upon what are supposed to be the actual chronicles of history.

Now mathematical formulæ have just such a pseudo-reality. They may be mere idealities and yet true, and they may be given actual existence and become false.

I give an abstract form to the formula, and write $\frac{6}{2} = 3$. Here we have a well-known truth. But if I attach a concrete value to the figures the result may be mere nonsense; for instance $\frac{6 \text{ sheep}}{2 \text{ butchers}} = 3$?

In fact the concrete values must be of one order, or must have a natural relation among themselves.

Now let us see whether and why the abstract $\frac{E}{R} = C$ represents concrete facts and truths. To this end we must clearly understand *what the symbols represent.* Of course every one knows that E stands for electromotive force; R for resistance; C for electrical current. But if these are three distinct actualities, concrete existences, how come they to hold among themselves the relations involved by the

formula? E, then, is electromotive force. But what is electromotive force? A force tending to set electricity in motion; or, to use a better phrase, to set up that motion which we call electricity. Here it will be seen we have at once two considerations presented to us: an effect, the motion produced; a cause, the force producing the motion. Of these the first, the motion, is of necessity an actual thing, though we may hold different ideas as to what the thing itself really is. But does the force exist, that is to say, as a special force? There are actual forces having real existence, such as the various attractions, of which we may take gravitation as the type; these are, so to speak, self-existent—we know not their causes. But there are other agencies which we call forces, yet which have only a temporary existence; they are, in fact, simply transfers of energy.

Any agency may be called a force which is capable of setting up motion, or altering the conditions of motion, in a mass of matter. Thus, if we take a ball of lead and let it fall, motion is imparted to it by gravitation; we may push the same ball of lead along a table, or by muscular energy hurl it to a distance; we may strike it as a cricket-ball is put in motion, by a percussive blow; or we may, by aid of a gun, set it in motion by means of compressed air or by the explosion of gunpowder. In all these cases motion is produced, and we may call the agent in each case a force. We may even embody all these agencies in one expression and attribute the motion generated to the action of a "Mechanico-motive Force," the intensity of which we can measure by the amount of motion produced. Such an expression might be correct enough mathematically, but physically it would be a delusion, for only in one instance, that of gravitation, is there an actually existing agency, properly called a force, at work. But any mechanico-motive force can be compared to gravity, because all can be expressed in terms of the velocity which has been set up, or which can be imparted to a unit mass of matter in a unit space of time; the force of gravitation on this earth being such as to generate a velocity of 32 feet per second in round numbers, or an actual motion of 16 feet per second.

But gravitation, and all similar natural forces of the nature of attraction, are constantly acting (and such attractive forces as electricity and magnetism increase during their action, because the distance diminishes), and, in consequence, its effects are cumulative, and result in a regularly accelerating motion, while the other forms of force noticed are simple impulses, and set up a fixed velocity at the origin of the motion. We may, however, for some purposes of reasoning, ignore this property of gravitation, and consider only its unit action, as I shall do presently, in order to make some comparisons with electromotive force.

Now, then, what is electromotive force? When we dissolve zinc in a battery, this force makes its appearance. It is said by some to be due to the contact of the two dissimilar metals; that at the point of contact there is a sort of attraction or repulsion which decomposes the supposed natural or normal electricity, and sends the two halves to seek reunion through any roundabout or difficult path. But one thing is certain—this force can do no work unless it is maintained by an equivalent supply of energy, and as a matter of fact easily proved, the degree of electromotive force produced is measurable in terms of the chemical actions which occur; and, speaking roughly, it is proportional to the difference of the tendencies of the two metals to combine with the radicals of the acids acting; that is to say, to the heat generated by these metals in the act of combination.

But if we expose the junctions of two different metals to heat, we find electromotive force set up in degrees depending (1) upon some inherent property of the metals (which has an appearance at all events of supporting the contact theory of its origin); and (2) upon the different temperature produced, which means in fact the quantity of energy which can be thrown into the circuit.

Again, if we move a conducting body in the neighborhood of a magnet in certain directions, we find electromotive force in action: here no contact of different metals exists to account for the fact; but an amount of energy is absorbed proportionate to the forces.

On examining the various modes of developing electromotive force, we find, in fact, that it always involves an absorption and distribution of energy, and that the same principles are involved as in the case of what I have called mechanico-motive force; but we find in no case (except apparently in the attractive force of static electricity) any force analogous to gravitation, or to any of the natural attractive forces. Electromotive force is constantly acting upon the circuit, but it has no accelerating action. We are therefore forced to the conclusion that it has no actual existence, but that, like mechanico-motive force, it is simply an application of energy.

E, then, in Ohm's formula is simply an expression, valuable in use for calculation, but symbolizing not a thing, but a value, a quantity of energy applied in a specific mode, to produce a definite molecular disturbance in a conductor and a propagation of electrical action. This will be seen more completely by-and-by.—*English Mechanic.*

ON SIMPLE FORMS OF MICROPHONE RECEIVERS.

By W. J. MILLAR, C.E.

THE following are notes of experiments made by the author upon various forms of microphone receivers. When studying the action of a galvanometer needle under the action of a current of electricity, it occurred to the author that if the needle were replaced by a bar magnet not free to move, sounds might be produced. This seemed more likely from the author's experiments upon "Transmission of Sound by Wires,"* where the strains induced in the wires by the aerial vibrations were reproduced to the ear again at varying distances from the origin. A small bar magnet, 3 in. long, having a number of turns of covered copper wire passed along it lengthwise, was connected with a battery consisting of a single Leclanche cell, weakly charged; it was then found that, upon breaking contact, scraping sounds were heard in the magnet. On placing a pasteboard box, or better still, a small tin plate upon the flat side of the magnet, these sounds were much intensified (see Fig. 1). A horseshoe magnet (Fig. 2), 6 in. long, was then tried in a similar manner, and it was found that the sounds were much stronger. Afterwards a bar magnet, 4½ in. long, having about 10 yards of No. 30 wire passed lengthwise along it and placed in a small tin box, the magnet being kept in position by a lid of tin fastened down above it, was tried and found to make an excellent receiver. With all these arrangements, when a microphone, of the ordinary vertical type, was placed in the circuit, various sound phenomena could be reproduced, such as speaking, whispering, singing, musical sounds, etc. On placing the small 3 in. magnet with its covering of wire in a shallow wooden box, it was found that the sounds were as well heard when the ear was placed against the wood as against the tin plate fixed down on the magnet. When any of these receivers were placed on the edge of a tin box, the sounds due to breaking contact were much intensified.

In the above receiver a permanent magnet was used, but some very curious results were obtained without the aid of the permanent magnet. A piece of tin, 2 in. diameter, was taken, and about half-a-dozen yards of covered copper wire passed around it first in one direction, and then at right angles (see Fig. 3); a couple of plates of tin were placed one on each side of this first plate, and the whole placed in a box. With this arrangement, musical sounds, breathing, etc., were transmitted; the word sounds were low and indistinct. About half-a-dozen yards of the same wire were wrapped round the middle part of a ferrotype plate (see Fig. 4); tuning-fork sounds and the ticking of a watch were transmitted when the plate was tightly pressed to the ear. An additional loose ferrotype plate placed on the former did not, in this case, improve the results.

The scraping sounds due to breaking contact are readily obtained by simple combination of wire and iron. Thus a turn or two of wire around a tin plate, a rod of iron, or along a few iron nails rolled up in paper, is sufficient for the emission of sounds when placed against a tin plate and the whole pressed to the ears. When the ferrotype plate and wire mentioned above were placed on the flat side of the horse-shoe magnet, the wire lying parallel to the limbs of the magnet, an excellent receiver was obtained (Fig. 5), the ticking of a watch being well and clearly defined.

Some experiments were made with this latter form, and it was found that when the wire was passed round other substances than tin or ferrotype, such as wood, pasteboard, or zinc, and placed on horse-shoe magnet as above (see Fig. 5), the sounds were still obtained. A single turn of wire, about 6 in., round a piece of pasteboard, was found sufficient for the emission of sounds, when placed on the horse-shoe magnet.

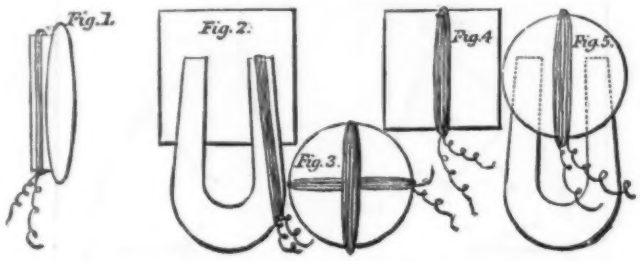
It was also observed that when the wooden plate was placed so that the wrapping of wire formed varying angles with the longer axis of the magnet, various tones were produced; these also varied as the plate was moved towards the center of the magnet.

In all cases the strongest sounds were obtained when the plates were nearer the poles than when at or near the middle. Square pieces of tin plate usually emitted stronger sounds than rounded pieces.

The tin plates were allowed to lie as close to the magnets as the magnetic attraction allowed of, no attempt being made to keep them from touching the surface of the magnet.

When the connecting wires were fastened to the ends of a bar magnet so as to make the latter part of the circuit, the sounds due to breaking contact were heard when a piece of tin was laid on the side of the magnet.

* Communicated to Physical Society, 1878.



NEW MICROPHONE RECEIVERS.

From his experiments the author concludes that the sounds originate in the magnet, and that the iron plate being closely connected with the magnet re-enforces these sounds. This it may do either as simply an extension of the vibrating surface, or as an extension of the magnetized body; any change in the magnetic field due to the passage of the current will be spread over a larger area. When a large tin plate, such as the lid of a box, was placed on the magnet, the vibrations could be felt by hand as a tremor through the metal. So far as the author has observed, clearness of articulation has depended on the condition of the microphone carbon transmitter and the volume of sound affecting it, rather than upon any nicety of arrangement of the receiver. With the arrangements tried, speaking about one foot back from microphone gave best results. Violin music was always beautifully and readily transmitted; singing and breathing were also transmitted without difficulty.

FULLER'S ELECTRIC LIGHT.

AN improved induction apparatus for lighting by electricity, invented by the late J. B. Fuller, is shown in perspective by Fig. 2, and in section by Fig. 1. The inventor's aim in the construction of this apparatus is to operate along the main electric circuit a large number of small lights, each being placed in a local circuit, whose currents are induced by the currents of the main circuit. Two magnet cores are arranged parallel with each other, and connected magnetically at the ends, as shown in Fig. 1. Around the

FIG. 2.

center of each of these cores is a soft iron head, and at a short distance from each side of this is a head of insulating material. The outer ends of the cores are coiled with insulated copper wire, and so connected together and to the electric generator as to produce, when in action, two consequent opposite magnetic poles, at N and S. A, B, C, D, and E, represent the connections of these coils. Between the iron heads and these coils are wound smaller coils of insulated wire, the fineness of which depends upon the tension of the current required.

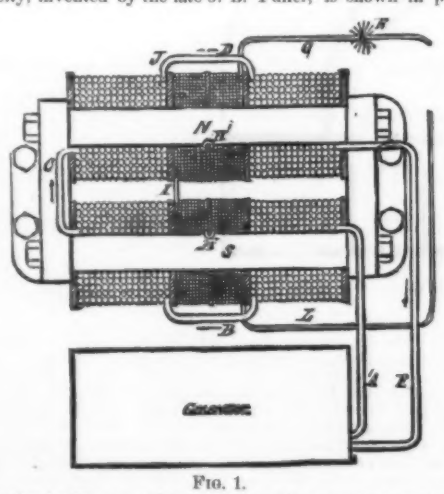


FIG. 1.

There is an iron arm hinged to one of the iron heads, so as to swing over upon the seat connecting magnetically the poles, N and S, as shown in Fig. 1. Now, if electric currents be sent through the main circuit, flowing around the large coils, and rapidly changing, in alternately opposite directions, the magnet cores will as rapidly change polarity, and these changes will induce in the small coils electric currents of greater or less tension, according to the fineness of the wire composing the small coils.

In the circuit of each of the small coils may be placed a lamp, F, of minimum illuminating capacity. Two small coils may be connected together, parallel or in series, for producing a light of medium capacity; or four small coils may be connected, for producing one light of maximum capacity, as shown in Fig. 1.

These connections for producing any changes in the circuits are made by means of ordinary switches, plugs, or keys. The arm which extends across the face of the coil in Fig. 2, acts as a governor of the light, by strengthening or weakening the magnetic poles, and thereby varying the strength of the current.

Any number of such apparatus which the electromotive force of the generator will supply may be arranged along the line of a conductor, the large coils being included in the circuit, and, by means of a switch in the local circuits, each or any lamp may be lighted or extinguished independently from the others.

M. ADER'S TELEPHONE WITHOUT A DIAPHRAGM.

By M. LE COMTE DU MONCEL.

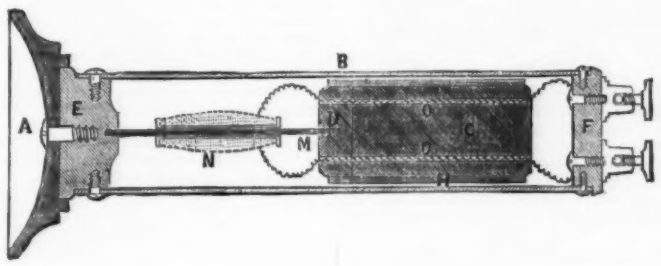
THE actual form of the telephone of M. Ader is shown on the next page, which represents a longitudinal section of the instrument. The difficulty which was presented in the first instance was that of acoustically insulating the two extremities of the iron wire which is terminated at each end by metallic masses. In order to solve this problem, it was found necessary to envelop one of the two masses in India-rubber, so that this mass could be placed in a metallic case fitted to the other mass, so that no confusion of vibrations resulted.

When simple voltaic currents are employed to make the instrument work, a well-annealed iron wire must be employed; but, if induction currents are used, as in the Edison system, which allows the apparatus to work to a long distance, the iron wire should be replaced by a strongly magnetized needle. The induced currents cannot work telephones constructed with a simple iron wire.

The telephone is extremely portable and efficient, and, moreover, is, in outward appearance, similar to the ordinary Bell telephone.

In the figure, the following are the several parts:

A. Ear-piece of wood.
B. Outer case.
C. Mass of lead.
D. Copper disk soldered on the lead.
E. Copper mass.



F. India-rubber mass.
H. Flexible envelope of India-rubber for insulating the vibrations of the mass, C.
M. Bar of iron one millimeter in diameter, well annealed, and soldered to the mass, E, and to the disk, D.
N. Olive-shaped bobbin wound with fine insulated wire, and placed in the middle of the iron bar.
O O. Holes through the lead mass through which the conducting wires pass.

The whole mass, C, D, does not fit tightly in the case, B, but has about a millimeter of space around it.

CHANGES OF SPECTRA.

IF a small quantity of mercury is placed in a hydrogen Geissler tube, E. Wiedeman finds that an induction current gives the hydrogen spectrum at ordinary temperature. But if the tube is warmed in an air-bath, as the temperature rises the mercury lines appear, while the hydrogen lines grow fainter and finally disappear. If a tube of hydrogen and nitrogen is warmed at any point, so as to free sodium or other metals from the glass, the hydrogen and nitrogen lines vanish almost entirely while the lines of the metal appear. Does the hydrogen disappear, or is it transmuted into some other substance?—*Comptes Rendus.*

J. B. FULLER.

ONE of the early friends and associates of Edison* was a young man named J. B. Fuller, a Connecticut Yankee, in whom the inventive faculty was active from boyhood. Fuller made a great deal of telegraph machinery and invented many industrial processes, such as modes of utilizing wood pulp in paper making, etc. Ten or fifteen years ago, Fuller separated from Edison, because it would no longer do to have them work in company. The inventions of the one might easily have been said to be due to the suggestions of the other, and so the two men parted, never to see each other again. They were men of very different qualities, Edison being quick to seize upon a new thought in natural science and apply it to practical use long before any one else could see its practical value, while Fuller loved deep problems and research, and was much more gifted in the work of discovering new principles than in applying them. He was an eager student and a desperate worker, and succeeded in mastering so many of the mathematical and other problems connected with electrical science that he became the greatest authority thereon, particularly on magnetic induction, in this country. Fuller took up the subject of the electric light in 1874, and has been studying it, in an obscure laboratory in Brooklyn, until the present year. He found at the outset, like so many other men, that there was need of a good magneto-electric machine. He invented his own, based on the principle of Gramme's, and produced so powerful a one that three years ago he succeeded in having it adopted by the Gold and Stock Telegraph Company of this city for practical telegraphy. The company named has over a thousand machines in different parts of the city, upon which are printed every few minutes the quotations of stocks in Wall Street through the business hours of the day. The Fuller magneto-electric machine was adopted to operate the wire connecting with these gold and stock indicators. Fuller has studied ever since to improve his generator; but when he had once obtained a generator of reasonable power, he returned to experiments with a lamp. He shunned publicity, and in the obscurity of his little shop toiled for years over his lamp. He was the man best fitted in the United States to attempt a solution of the problem. This inventor evolved a whole system of lighting—the generator, a lamp, and a meter. He proposed to use two large street mains, one of them insulated, disconnected at the outward ends. The positive main was to throw off a branch wire into each building to be lighted, the wire entering the meter, performing a certain service there, and then returning to the street to the negative main. The main current was not to do the lighting, but it was to generate another current in a series of induction coils, and each lamp was to be lighted by the current, from one of these coils. An alternating current was to be used. The induction coils were thus made: Two magnet cores, arranged parallel to each other, were connected magnetically at the ends. Around the centers of each of these cores was a soft iron head, and at a proper distance from this a head of insulating material. The outward ends of the cores were coiled with insulated copper wire, and so connected together and to the main wire (or generator) as to produce two opposite magnetic poles. Between the soft iron heads and the coils were wound smaller coils of insulated wire, the fineness of which would depend on the tension required. To one of the iron heads was hinged an iron arm, so made as to swing over upon the other, connecting magnetically the poles N and S. In a coil so made, if a current be sent through the main wire rapidly changing in opposite directions, the magnetic cores will change polarity, and the change will induce a current of great tension in the smaller coils, and this second current, if conducted by proper wires to a lamp, will maintain platinum or carbon in a high state of incandescence. Two induction coils, or four, can be coupled together for lights of stronger power. A graduated switch is used in this lamp, so as to permit its brightness to be varied at will. A great many experiments were made with this style of lamp with platinum burners, and they operated admirably. A number of capitalists of Brooklyn, hearing about these experiments, organized a company, with 1,000,000 dollars capital, last December, to adopt Fuller's inventions and introduce his light throughout Brooklyn. A new shop was fitted up for the inventor on Broadway, near 36th street, in New York City, near his residence, and in this shop Fuller toiled for six months almost literally day and night. His whole system was in a most promising shape, when last February an incident occurred which put a stop to the progress of experiments in household lighting.

The company had determined to manufacture point-to-point lamps and magneto-electric machines first for factory use. About twenty factories in New England and the Eastern States have this winter introduced the large electric lamps of from 700 to 2,000 candle power into their workrooms, and the demand for the means of lighting had become very active. The Fuller Company resolved, therefore, to solicit orders from factories, and it had 75 machines constructed, which are being finished up this week for factory use. During the first week of February, Mr. Fuller was engaged in perfecting a new point-to-point lamp, and began to be troubled with insomnia. Against the advice of his friends, he worked on his new lamp until it was finished. In the act of tightening up the last screw he fainted and fell to the floor of his shop entirely exhausted, completely worn out with intense mental application and lack of sleep. He was carried to his residence. A week afterward he had recovered so as to be active again. His busy mind had, in the meantime, discovered a new idea in induction. He sent over to the shop for his man George, the foreman of the works, to explain to him the new idea. The two men sat down together, and Mr. Fuller described his idea with much minuteness—the shape of the magnets, the size of the wire, the manner in which the wire was to be coiled on, and so on, motioning with his hands to illustrate his meaning. When Mr. Fuller had finished, he said: "George, do you understand that?" The foreman replied that he did. "Now," said Mr. Fuller, "I want you to understand that, George, for it is very important;" and then he went over the matter again, explaining the whole idea, with the mathematical principles involved in it. When he had completed the explanation the second time he said: "Now, George, do you think you understand that?" The foreman said he did perfectly. Mr. Fuller looked pleased, lay back in his chair, and died soon afterward. This was on the 15th of February. The inventor's life had flickered out, quietly, but unexpectedly to both men, and Mr. Fuller, as every one who is acquainted with his plans believes, has departed just it the moment when he was about to become famous and rich. His foreman was of a too practical turn of mind to see the poetic aspect of such an incident, and it is only within a day or two that the facts have been privately obtained by the writer.—*New York Correspondent of the London Times.*

* Edison says this story is all fiction. He was never associated with Mr. Fuller.—I. R.

GAS AS FUEL.

By "ISCA"—(*Journal of Gas Lighting*).

IT must be remembered that a given weight of any fuel will always yield the same amount of heat, so that the heat developed, say from coal in a common grate, is equal to that which would be given by the same quantity of coal in the largest blast furnace. Similarly, the heat of an ordinary lucifer match, or the flame of a tallow candle, is not one whit less than that yielded by an equal weight of wood or tallow burning in the heart of a great conflagration.

No kind of furnace or arrangement of draught can increase the value of any sort of fuel. The only duty of artificial appliances of that nature is to provide for the admission of the necessary amount of air to effect the oxidation of so much carbon or hydrogen, or both, as may be required within a certain period of time. The more carbon a combustible contains, the less ready is it to combine with oxygen, and therefore it is found that with almost pure carbon in bulk—as hard coke for locomotives, etc.—the strongest blast is necessary to cause its complete conversion to carbonic acid.

There are only two means by which the quick and complete combustion of fuel may be effected. The first and most usual is to urge a large quantity of air over and through the great masses of incandescent material; and the other method is that of reducing the fuel itself to a state of fine division, whereby its active service is so much increased, that, when intimately mixed with the proper quantity of air, and brought under suitable conditions, the process of oxidation of each particle is effected *per saltum*.

The theoretical reasons for the latter mode of treatment are perfectly sound, but the efficacy and handiness of the apparatus which has been employed to carry them out has left much to be desired; and the practical advantages which have been actually realized are not such as to cause the general adoption of any of the methods which have been introduced for this purpose. It is, however, on record that powdered coal has been perfectly consumed by the admixture with it, in the furnace, of the exact weight of air theoretically necessary; so that it is evident that this desirable object can be attained in the use of fuel in a more suitable form than in solid lumps borne on fire-bars in the usual way. Of course, fuel in this shape can only be used for steam-boilers, iron furnaces, and similar trade purposes.

The step from fuel in powder to fuel in liquid form is not difficult. If we agree with the arguments in favor of the former, it must be admitted that they apply with great force to the latter. If continuous firing is of any value—and no one would deny that it is so—a fluid can be caused to flow to any desired point with the greatest regularity, and can also be made to take any desired quantity of air with it. An oil is always ready for lighting, and, from the time when it is first set on fire to the last drop, it can be consumed to its fullest power, and without residue of cumbersome and useless matter. As a source of heat under perfect control, and capable of being used in small quantities and without a furnace, oil has only one rival—in gas; and, in point of portability, it is undoubtedly superior to any other combustible. As long as the oils in common use for illuminating purposes were derived from animal or vegetable sources, their cost was such as to preclude their general use as fuel, for which, indeed, they were not eminently qualified; but the cheapness of mineral oils, not less than their calorific power, has led to their common employment as fuel for certain purposes.

Alcohol has always been in demand as a handy source of heat for small requirements, for which its highly inflammable nature—consuming without depositing soot—renders it very convenient; and although its real heating power is not large, it is readily available. Its costliness, however, even in the form of methylated spirit, is its great drawback.

Bearing these preliminary observations in mind, together with other considerations respecting the comparative suitability of different fuels for ordinary purposes which must occur to every one, the following tabular statement, compiled from various authorities, of the composition and value of various combustibles in common use, will be found useful:—

TABLE OF THE AVERAGE COMPOSITION OF FUELS.

FUEL.	Components per cent. by Weight.							
	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Sulphur.	Ash.	Water.	Estimated Value in Units per Pound
Hydrogen	—	100	—	—	—	—	—	62,500
Carbon	100	—	—	—	—	—	—	14,500
Coal—								
Welsh	83·78	4·79	4·15	0·98	1·43	4 91	—	14,817
Newcastle	82·12	5·31	5·69	1·35	1·24	3·77	—	14,776
Lancashire	77·90	5·32	9·53	1·30	1·44	4·88	—	13,776
Derbyshire	79·68	4·94	10·28	1·41	1·01	2·65	—	13,841
Scotch	78·53	5·61	9·69	1·00	1·11	4·03	—	14,136
Averages	80·40	5·19	7·87	1·21	1·25	4·05	—	14,289
Coke—								
Dry and fresh	92·00	—	—	—	0·50	7·50	—	13,340
Average state	84·75	—	—	—	0·75	7·50	7·00	12,288
Wood—								
Perfectly dry	50·00	5·30	41·70	1·00	—	2·00	—	7,312
Ordinary state	40·05	4·20	33·40	·75	—	1·60	20·00	5,826
Lignite, dry	69·00	5·00	18·80	1·20	—	6·00	—	10,661
Peat	45·30	4·60	23·00	1·00	—	1·80	24·20	7,649
Wood charcoal	92·00	—	—	—	—	8·00	—	13,340
Petroleum	85·00	13·00	2·00	—	—	—	—	20,293
Petroleum oils	72·60	27·40	—	—	—	—	—	27,652
Olive oil	77·21	13·36	9·43	—	—	—	—	18,808
Alcohol	51·98	13·70	34·32	—	—	—	—	13,403
Tallow	79·00	11·70	9·30	—	—	—	—	18,042
Beeswax	81·00	13·90	4·50	—	—	—	—	21,169

Some kinds of fuel, but more particularly the solid forms, are commonly found saturated with water, which depreciates their value in two ways—first, by the actual loss of material due to the weight of water present, and bought, it may be, at the price of the dry combustible; secondly, by the amount of heat which that water abstracts from the fuel in being raised to the temperature at which its vapor leaves the furnace with the other products of combustion, and which amount is, of course, diverted from its proper object, and therefore lost. And when a combustible contains oxygen and hydrogen among its constituents, they are considered as being already in the form of water, and therefore it is only the excess of hydrogen over the equivalent weight which will unite with the whole of the oxygen present to form aqueous vapor, which can be estimated to give any useful effect.

The composition of coal gas is so varying with different samples, that it is difficult to assign a particular value to it, as may be done in the case of most other combustibles. The following analysis of gas, which is deduced from an example given in the *Journal of the Franklin Institute* of America, for February, 1879, may, however, be taken as a sample of gas as supplied throughout the country; and, not being of very high quality, the total of its heating power will not be open to question as being a too favorable result:

TABLE OF THE PROPORTION BY WEIGHT OF THE CONSTITUENTS OF ONE POUND OF COAL GAS.

Symbol.	Component.	—	Hydrogen.	Carbon.	Oxygen.	Nitrogen.	Heating Power in Units.
H	Hydrogen	·0731	·0731	—	—	—	4,573·4
CH_4	Marsh gas	·4728	·1182	·3546	—	—	12,530·8
C_2H_4	Olefiant gas	·1844	·0307	·1536	—	—	4,149·1
CO	Carbonic oxide	·1363	—	·0584	·0779	—	598·0
CO_2	Carbonic acid	·0716	—	·0195	·0520	—	—
4N+O	Air	·0469	—	—	·0104	·0365	—
H_2O	Vapor of water	·0146	—	—	·0129	—	—
—	Coal gas	1·0000	·2237	·5863	·1534	·0365	21,851·3

This result closely approximates to the value assigned by Dr. Letheby, which is 21,060 units per pound; the difference, slight as it is, being susceptible of reduction when the lower value assigned by him for hydrogen is taken into account.

It will now be necessary to state the calorific power of coal gas in respect to its bulk, that being the basis of its usual conditions of sale and consumption.

TABLE BY WEIGHT OF THE CONSTITUENTS OF ONE HUNDRED CUBIC FEET OF COAL GAS IN POUNDS AND DECIMALS.

Symbol.	Component.	—	Hydrogen.	Carbon.	Oxygen.	Nitrogen.	Heating power in Units.
H	Hydrogen	·23340	·23340	—	—	—	14,589·146
CH_4	Marsh gas	1·50835	·37709	1·13126	—	—	39,973·252
C_2H_4	Olefiant gas	·58823	·08403	·50420	—	—	13,235·629
CO	Carbonic oxide	·48488	—	·18638	·24850	—	1,907·620
CO_2	Carbonic acid	·22846	—	·06231	·16615	—	—
4N+O	Air	·14995	—	—	·03332	·11663	—
H_2O	Vapor of water	·04662	·00518	—	·04144	—	—
—	Coal gas	3·18989	·69970	1·88415	·48941	·11663	69,705·647

ANILINE (C_6H_7N).

THIS alkaloid, which is now the pivot upon which a colossal industry turns, was discovered in the year 1826 by Unverdorben, while investigating the products of the destructive distillation of indigo. He noticed its property of forming readily crystallizable salts, and, on that account, gave it the name of crystalline. It has at different periods received the names of kyanol, benzidam, amido-benzene, and phenylamine.

Shortly after its discovery by Unverdorben, Runge, in the course of his memorable researches on coal tar, separated from that substance a basic body possessing the characteristic property of yielding a blue coloration with a solution of chloride of lime, and, not knowing that it was identical with Unverdorben's crystalline, gave it the name of kyanol.

Subsequently Fritzsche, while examining the products of the distillation of indigo with potash, observed the principal portion of the distillate to consist of a basic oil, to which he gave the name of aniline, from *anil*, the Portuguese name for the indigo plant. About the same time Zinin discovered the important fact that an alcoholic solution of nitrobenzene, by treatment with sulphide of ammonium, yielded a volatile oily alkaloid, to which he gave the name of benzidam.

The relation of the substances known under the above names to each other was not understood until Hofmann undertook a comparison of the supposed different alkaloids from all the above sources, and demonstrated their identity. It is, in fact, to Hofmann that chemistry is indebted for first throwing a clear light upon the constitution and metamorphoses of aniline. His researches were not only of the most laborious and searching character, but the brilliant results they afforded gave an insight into the nature of organic alkaloids generally which has been of incalculable service not only to science but also to industry.

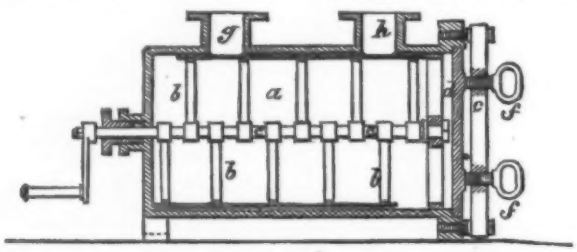


FIG. 1.

Aniline is now prepared on a large scale exclusively from nitrobenzene, and almost always by the process of M. Béchamp (Compt. Rend. de l'Acad., xxxix. 26) which yields it more readily and economically than any other. Indeed, it is not too much to say that the commercial production of aniline colors would never have arrived at its present magnitude but for this discovery of M. Béchamp. The process consists in reducing nitrobenzene by ferrous acetate. The nature of the reaction will be evident from the annexed equation:—

$$C_6H_5NO_2 + 6\,FeO + H_2O = C_6H_7N + 3Fe_2O_3.$$

Nitrobenzene. Aniline.

The acetic acid does not enter into the decomposition, and is, therefore, omitted from the equation.

On the large scale, the nitrobenzene, prepared and washed as previously described, is decomposed in vertical or horizontal cast-iron cylinders. The Messrs. Perkin, who were the first to manufacture aniline on the large scale, employed cast-iron cylinders of the form represented in Fig. 1. The cylinder, *a*, had an axis, *c c*, passing through it, carrying the agitators, *b b*. As originally made, the latter was turned by manual labor; but it is now invariably done by steam power. The horizontal axis or shaft passed through a stuffing-box at the end, near the handle by which it was rotated. The movable cast-iron cover, *d*, was kept in its place by the bar, *e*, through which passed the pressure screws, *f f*. The opening, *g*, served to enable the materials for the reaction to be introduced, and the tubulature, *h*, enabled the distilled product to be conducted to the apparatus for condensation. In the earlier days of the aniline manufacture Messrs. Perkin employed Woulfe's bottles of stoneware for that purpose: but cast-iron worms are now almost invariably used. The flange of the cylinder against which the cover presses was covered with a coarse kind of putty. The cylinder was set in brickwork, and the operation conducted by fire. The flues were so arranged that the flame was prevented from playing directly on the cylinder, as in that case it would soon have become permanently injured. An inch of bricks (or a large cast iron or fire-clay plate) was, therefore, interposed between the cylinder and the fire-place. By some mistake this apparatus is described by MM. Girard and De Laire as that used by Messrs. Perkin for the manufacture of nitrobenzene by means of nitrate of soda and sulphuric acid.

The apparatus for the conversion of nitrobenzene into aniline may be made in a great variety of forms. The operation is so simple and so easily conducted that no manufacturer will find any difficulty in devising an arrangement for the purpose; that described by MM. Girard and De Laire for effecting the conversion of nitrobenzole into aniline may be considered as illustrating all that can be required in such an apparatus.

The cast-iron cylinder, *a a'*, in Fig. 2, is made in two parts; they are joined together by flanges and screws, as shown in the engraving. The agitator, *b b*, can be rotated by the hollow shaft, *c*, which allows steam to enter the apparatus through the holes, *e e*, in the agitator. The pipe, *j*, supplies steam from the boiler, which enters the hollow shaft of the agitator at *d*, the supply being regulated by a screw-valve, *k*. Two man-holes are represented at *f f*; the lower one serves to enable the residue of the operation to be removed. The opening, *g*, enables the iron borings to be introduced. The nitrobenzene and acetic acid are introduced into the apparatus from the reservoir, *h*, by the siphon or S-shaped tube, *g'*. The aniline and the other products of the reaction escape by the tubes, *i i*, and thence proceed to the condensing worm. The rotation of the agitator is effected by means of the pulleys, *l l*, and the bevel wheels, *m n*.

Although the apparatus described is typical in its completeness, it is certain that any intelligent engineer could construct an arrangement equally perfect in action but much less costly. The separation of the cylinder into two portions is not essential, and there is an element of weakness in having the rotating shaft, *c*, constructed hollow. The steam can easily be introduced in a simpler and cheaper manner; in fact, a still for the reduction of nitrobenzene can readily be constructed from any cast-iron pot having a broad flange round its upper edge. The size of the apparatus must be regulated by the quantity of nitrobenzene which it is desired to convert at each operation.

The method of carrying out the reduction is susceptible of considerable variation. Supposing that 500 pounds of nitrobenzene are to be reduced, we may commence by running in through the siphon, *g'*, 40 pounds of acetic acid of a specific gravity of 1·06, diluted with five or six times its weight of water; in subsequent operations the acid distillate from a previous operation may be substituted. The rotation of the agitator is now to be commenced, and one cwt. of cast-iron borings, finely ground, may be inserted at the tubulature, *g*. The nitrobenzene should now be run in, and the reaction at once commences. More iron is then to be gradually added, until it amounts to about 700 pounds. When the distillation has become rapid, from the heat of the reaction, the condensed liquid is to be received from the worm in stoneware jugs, and returned to the still from time to time until the nitrobenzene is found to have been almost entirely reduced. In order to ascertain this, the oily portion of the distillate may be dissolved in hydrochloric acid in a graduated tube, which is then to be filled up with water, and, after shaking allowed to repose. Two or three tubes may be employed, so as to enable the later testings to be compared with the earlier ones. When the operation is considered to be finished, steam is to be admitted by the screw-tap, *k*, and the products of the reaction distilled over.

The reaction must not be allowed to become too violent, as, in that case, the reduction of the nitrobenzene may proceed too far, and benzene be reproduced. According to Berthelot, even the aniline first formed may be reduced into benzene and ammonia.

The aqueous distillate contains acetic acid and acetone, as well as the aniline; and, as we have said, if the reduction has been too energetic, more or less traces of benzene.

The writer prefers to have the means of heating the aniline stills by fire as well as steam, in order to diminish to some extent the water in the distillate.

On the addition of caustic soda to the crude distillate, the acid present is neutralized and the aniline separates. To remove the aqueous portions, the whole may be introduced into iron cylinders, having one or two taps at different heights. By this means the watery fluid may be run off, and the aniline received in a state fit for rectification.

The residue remaining in the apparatus consists principally of ferric hydrate, which, the writer is informed, has been experimented upon on a considerable scale in Germany and France for the purification of gas. It is said, however, not to revive so readily as the ordinary oxide in general use.

The rectification of aniline is a matter of great importance, as its value for certain operations depends entirely on its boiling point. It must be remembered that commercial anilines are divided into two principal classes—"aniline for blue," which is, or should be, pure aniline; and "aniline for red," so called, but which consists chiefly of a mixture of the ortho, para, and meta toluidines.

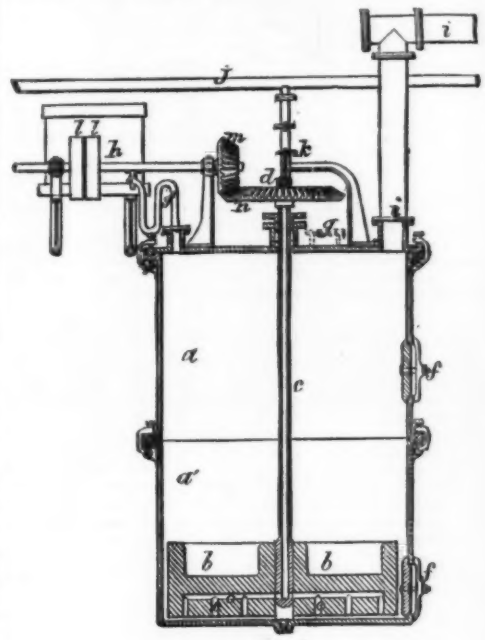


FIG. 2.

Anilines may be rectified in various ways. MM. Girard and De Laire describe an elaborate apparatus for the purpose, which is said to work well on the large scale. The nature of the aniline will depend upon the quality of the benzole or benzene used in the preparation of the nitro compound.

When commercial anilines are rectified over the naked fire in ordinary cast-iron stills, it is advisable not to push the distillation to dryness, as, in that case, the still soon becomes injured. The portions left behind contain xylidine, cumidine, azobenzene, acetanilide, phenylene-diamine, tolylene-diamine, paraniline, xenylamine, and probably several other substances. As, however, they are not of immediate importance, they will not be further referred to in this sketch of the aniline manufacture.

Aniline for blue should, as we have said, be as pure as possible. It may be obtained by repeated rectification of ordinary light anilines, or, preferably, by working in the first place on a benzene of the highest class. By the latter is understood one that has been purified by careful rectification, followed, if possible, by freezing.

It is not difficult now to find commercial aniline for blue distilling entirely between one or two degrees, or even less, as with the specimen described below.

The following determination of boiling points was made upon an aniline supplied by a well known French firm. The experiment was made in an ordinary retort, according to the method described in the article on boiling points at p. 511 of this Journal. The thermometer, T, was in the vapor, and a cardboard screen was used to prevent heating of the second thermometer, *t*, by the hot air arising from the lamp. The readings were taken when 10, 25, and 90 per cent. of the fluid had distilled over.

	T.	t.	N.	Temperature. Corrected.
10 per cent., at	179·5°	18·75°	108°	182·18° C.
25 " "	180·0°	21·75°	"	182·64° "
90 " "	180·0°	25·50°	"	182·57° "

MM. Girard and De Laire give 180° to 185° as the boiling point (uncorrected?) of a high glass aniline, prepared from crystallized benzene boiling between 83° and 84°. It will be seen that, if uncorrected, the boiling points of the aniline given above would have appeared to be two and a half degrees below that of a pure substance; but, as corrected, the results are exceedingly satisfactory.

Pure aniline is a colorless, oily liquid, having a somewhat vinous odor. However colorless it may be when first distilled, it soon becomes brown on keeping. Its specific gravity at 16° C. = 60·8° Fahr. is, according to Hofmann, 1·020. Its boiling point, according to the same authority, is 182° C. = 359·6° Fahr. It solidifies at —8° C. Its vapor density, as determined by Barral, was found to be 3·219; theory requires 3·234. It is decidedly poisonous. Workmen exposed to its vapor for some time have symptoms much resembling those produced by nitrobenzene; and the treatment recommended at p. 474 of this volume for poisoning by that substance may also be used where the symptoms have been caused by aniline. Workmen should not be permitted to enter stills or storing-tanks which have contained aniline, until they have been thoroughly cleansed. Care should also be taken that the men who attend aniline stills should not be allowed to inhale its vapor more than can possibly be avoided.

The stills should be placed in sheds open at one side, or in thoroughly well ventilated rooms; and the water in the condensers should not be allowed to get too hot. The workmen should also be warned against allowing their hands and

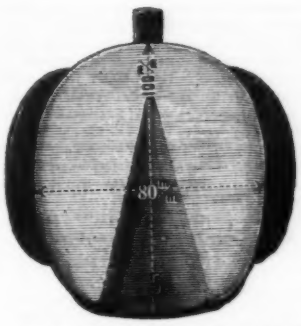


FIG. 1.—HANNOVERIAN HOOF CUSHION.

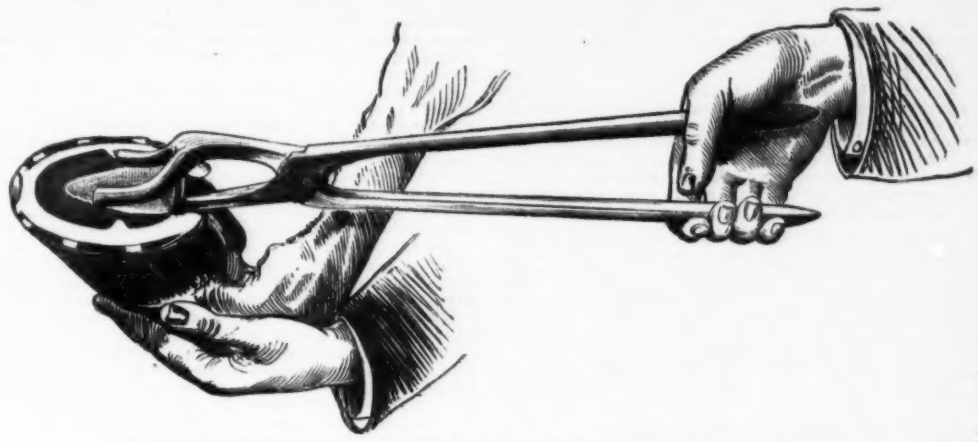


FIG. 3.—TONGS FOR PLACING THE SACHS HOOF CUSHION INTO THE SHOE

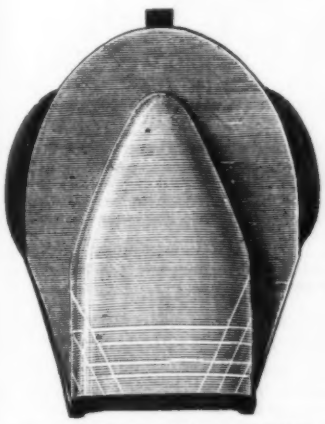


FIG. 2.—SACHS' HOOF CUSHION.

FIG. 4.—SACHS' HORSE SHOE.

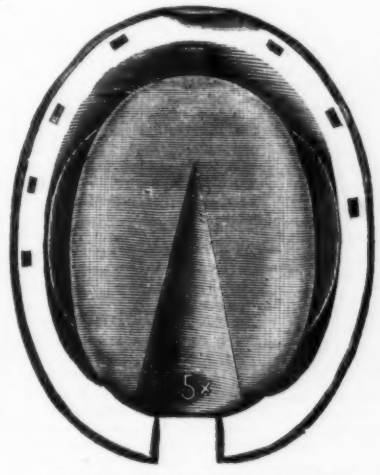


FIG. 5.—HANNOVERIAN HOOF CUSHION IN THE SHOE.

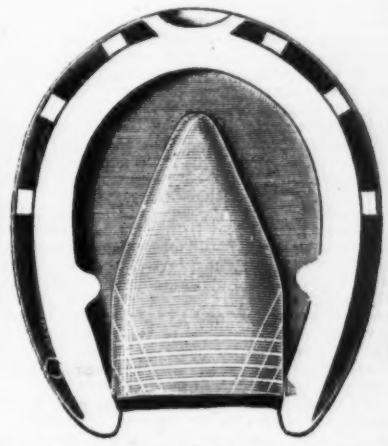


FIG. 6.—SACHS' HOOF CUSHION IN THE SHOE.

clothes to become wetted with the aniline, in pouring it from one vessel to another. With common care, no danger whatever need be incurred; and, during more than 20 years' experience, the writer has never seen a fatal case of poisoning by this substance.

Aniline dissolves to a small extent in water, but separates on the addition of an alkali or common salt. It also takes up a small quantity of water, the amount varying with the temperature. When subjected to distillation on the larger scale, a certain amount of water always comes over at the commencement.

Aniline may be detected, even in very small quantities, by the violet color which is produced on adding a few drops of a solution of chloride of lime to its aqueous solution. It colors deadwood a bright yellow. This reaction is very delicate, but not characteristic, as, unfortunately, several other bases do the same. A solution of hydrochlorate of aniline washed over a well planed deal board, yields a beautiful, and as far as the writer's experience has gone, permanent yellow stain. If a trace of an alkaline nitrite be placed on a fragment of solid hydrochlorate of aniline, it rapidly communicates to it a brilliant crimson color. So delicate is this reaction, that it is almost impossible to prepare colorless hydrochlorate of aniline near a place where alkaline nitrites are manufactured.

According to an observation of the writer, made many years ago, aniline at the boiling heat dissolves indigo, and deposits it, on cooling, in brilliant copper colored spangles. A description of the methods of converting aniline into coloring matters being foreign to the objects of this sketch, the reader desirous of further information is referred to works professedly dealing with that subject. The treatise of MM Girard and De Laire, and Watts' "Chemical Dictionary," may be consulted with advantage; the latter, and its Supplements, contain a great number of reference to the papers of English and Continental writers on aniline and its almost innumerable derivatives.—*Journal of Gaslighting.*

RUBBER HOOF CUSHIONS.

THE hoof of a horse has been so arranged by nature that the whole under surface touches the earth and bears the weight of the horse. If shoes having heavy calks, and two pieces are used, the center part of the hoof does not come in contact with the ground, and the entire weight is carried by the outside edge of the hoof.

To overcome this difficulty, it has been customary of late to place a cushion of India-rubber in the hollow formed under the hoof by the shoe. These cushions are made to suit the size and shape of the shoe.

The accompanying engravings represent the two different kinds of cushions that have come into use. Fig. 1 is the Hannoverian cushion, and appears, as it is shown in Fig. 5, when fastened to the shoe. Fig. 2 is the Sachs cushion, and is fastened into a shoe shown in Fig. 4, and then has the appearance of Fig. 6. Fig. 3 is a representation of a special kind of tongs, made for the purpose of fastening the Sachs cushion into the shoe. These cushions are very useful when driving on an icy or asphalt road, as by means of them the horse gets a firm hold. They last as long as four or five horse shoes, and can be readily removed or replaced.—*From Wiener Landwirthschaftliche Zeitung.*

DETACHING NEGATIVES FROM THEIR GLASS SUPPORTS.

[A Communication to the Photographic Society of France.]

SINCE emulsion processes came to simplify the hitherto complicated manipulations of photography and to render the art more practical when traveling, there still remains a gap to fill up—a step to make—in order to rid the traveler of his most cumbersome and heaviest load, and that which causes him the most anxiety; in a word, the glass upon which his films are supported. There is no photographer who has not suffered under these tribulations or who has not trembled in consequence of the fragile character of his productions; hence for some time numerous attempts have been made to detach from the glass the film carrying the photographic image, and to place it upon some other support at once light and unbreakable. Several processes have been published which I shall pass rapidly under examination.

Simple and Direct Transfer upon Gelatine.—Without referring to old methods, I shall speak only of those which have been indicated since the introduction of emulsions. M. Chardon has proposed to prepare sheets of gelatine in advance, and to use them to detach the film from the glass. This method answers well enough, but it is applicable only for carbon printing, because it gives reversed negatives, and, unless one has a special system of ventilation, gelatine poured upon a glass negative takes a long time to dry. I may even add that in the western regions of France, near the coast,* there are seasons of the year when it will not dry at all, and it is not long before it is covered with dust; it is, therefore, preferable to use the commercial sheet gelatine, which answers the same object and gives precisely the same result.

Mr. Woodbury has recommended the photographer to take when traveling a bottle of plain collodion and an alcoholic solution of gelatine. It is necessary to liquefy this solution in a hot water bath, and to pour it upon the negative just finished. The drying requires a few hours. We have here the same inconvenience—a reversed negative, which can only be used for carbon printing; besides, the gelatine dissolved in water and alcohol dries, it is true, in a few hours, but, as there enter into its preparation two liquids of different densities, the evaporation takes place unequally, and the effect is shown upon its dry surface by a series of small blisters. Had this process no other inconvenience than the necessity of carrying, when traveling, what I will call the "kitchen of photography," that would suffice to cause its rejection.

What the traveler requires is a paper prepared in advance, and with which he can in a few minutes detach all the negatives taken during the day; so that, in short, a few glasses would suffice for an excursion of any length, and on his return home it would only be necessary to transfer his negatives to some final support.

With this object Mr. Woodbury, I believe, worked out a remarkably ingenious process. He prepared an ordinary gelatinized paper with which he lifted the negative; afterward he attached it on reaching home to a glass, prepared with a film of gelatine and chrome alum, and immersed the two in warm water. The soluble gelatine released the paper, while the negative remained upon the insoluble gelatine of the glass.

In theory this method was perfect—the gelatinized paper easily detached the negative; but, according to trials I have made, besides the inconvenience of the long drying of the gelatine and chrome alum upon glass, the transfer of the paper negative to the gelatinized glass was rarely made in a good condition; because when the paper was detached by the immersion in hot water the insoluble film of gelatine expanded, then contracted in drying, and produced upon the pellicle of the negative a number of cracked lines. I send a specimen of this fault.

It is necessary, then, to find a paper prepared in such a way that one can detach the negative safely; that this paper applied to a sheet of gelatine will leave the negative after having been soaked only in cold water; and, further, that one can utilize the commercial sheets of gelatine, to avoid the otherwise interminable manipulations and drying. In a word, we require a sure process reduced to the most simple mode of operation. It is to this that I have applied myself, and I believe I have succeeded, because I operate in a uniform manner, and without any failures. I have, therefore, the honor to submit my process to the Society.

Preparation of the Paper.—It was necessary to search for a hygrometric adhesive substance to form a coating upon paper which would retain the negative and afterward part with it with the greatest facility. Here is how I prepare it: In 100 c.c. of water I dissolve on the water bath 25 grammes of gum arabic; to this I add half a gramme of gelatine and 3 c.c. of glycerine, which renders the gum less brittle. The solution is filtered through muslin into a tray, and I then float thereon a sheet of paper in the same manner as albumenized paper on the silver bath, turning down the upper corners of the sheet by which to hold it, and pin it up to dry. Care must be taken to avoid air bubbles. If they form they must be removed with the finger, and the sheet must be hung up perpendicularly with two pins to drain quickly and regularly. The paper may also be prepared by applying a coating of the gum with a flat brush. This is the most simple way, and requires less solution. A large stock can thus be made in a short time.

Raising the Negative Film from a Glass Plate (which ought to have been polished with Talc).—I place the negative in a dish of water, upon which I float the gummed paper cut to the size of the negative, and with a hook I raise the glass upon which the sheet attaches itself, and the water in running off draws with it any bubbles which may have formed. I withdraw carefully and then place the negative and gummed paper between two sheets of thick, smooth-faced, blotting paper. I place a sheet of India-rubber cloth over them, and then go over the whole lightly and regularly with a wet squeegee.

I insist upon these precautions to be taken at this point. It is necessary that the India-rubber cloth should be held fast, and that the squeegee, which is applied several times, should not be pressed too strongly, nor displace the gummed paper, which might tear the wet negative film.

That done, the excess of gum is run off. I then place the glass for several minutes, either in a printing-frame, or, when traveling, under a flat surface, charged with sufficient

* Coutances, in Normandy, where M. Magny resides.

weight to give pressure; after having withdrawn it from pressure I leave it to dry completely in a vertical position, which according to temperature, takes about an hour.

If, when the glass is taken from the pressure-frame and placed vertically, any swelling under the paper be seen, there need be no uneasiness: it is a little gum, still liquid, which will drain off, and the sheet will resume its flatness on drying. I finish by cutting round the paper one-sixteenth to one-eighth of an inch from the edge of the glass, and after having slightly damped it with a sponge scarcely wet I raise the negative by passing the blade of a penknife under the whole length of one side, and I then left off the whole with a regular movement. These operations, which the long and perhaps diffuse explanations seem to complicate, are performed in a few minutes.

Transfer of the Negative to a Sheet of Gelatine.—I immerse at the ordinary temperature a sheet of commercial gelatine in a tray of water, to which is added from three to four per cent. of glycerine, and cut one-twenty-fourth of an inch larger each way than the glass support. I leave it to soften and to extend completely, the length of time depending upon the temperature of the water. The gelatine is handled in the water like linen, and one judges its degree of suppleness by the touch. I slip underneath a glass previously coated with plain collodion, washed and dried, and with the hook I raise together the glass and the sheet of gelatine, as I had done the paper in the preceding operation.

I may here observe that the plain collodion only serves to protect the reverse side of the gelatine against damp, because, applied directly upon the talc-prepared glass, the gelatine detaches itself very well.

I then place the glass, well leveled, on three leveling screws, and squeeze out, with a flat brush well wetted, the excess of water from between the gelatine and the glass, as well as bubbles, if there be any. With the brush I drop as much water on the gelatine as its surface will retain, and I float upon it the gummed paper negative, commencing at the lower part and laying it down regularly toward the top, so as to drive out the excess of water.

I now raise the glass, which I drain for an instant, place it between two blotting papers, cover with the squeegee cloth, and pass the wet squeegee over the whole as in the preceding operation, and with the same precautions. The blotting paper must be raised with care so as not to lift either the paper or the gelatine.

I next turn under the edges of the glass the borders of the gelatine which overlay it; this is easily done by placing it in the printing frame for about half an hour or an hour until the gelatine is set; and I leave it then to dry spontaneously until when touched by the hand the paper is no longer humid but fresh. After this I plunge the glass, thus covered, in a tray of cold water, and in two or three minutes I lift up gently a corner of the paper, which detaches easily, leaving the negative on the gelatine. The image is rinsed to carry off all traces of the gum, and it only remains to leave it to dry completely.

I recommend not to hasten the desiccation, which is not a lengthy operation, by an elevation of the temperature; it is better to dry in a cool place, or the sheet of paper may have a tendency to detach itself from the glass before completely dry. The borders of the gelatine folded underneath the glass have the additional object of retaining it in contact.

Finally, when the sheet is really dry it is cut at a short distance from the edges of the glass and detaches itself without difficulty. The negatives, thus detached, may be retouched with the greatest facility.

If it be desired to have a reversed negative nothing is more simple. It suffices to soften, as I have before explained, a sheet of gelatine in a tray of water to which glycerine has been added, to slide under it the negative upon the (original) glass, and to raise the two with a hook, to remove the waters and bubbles with the wet, flat brush, and to leave it to dry vertically. After desiccation pour on plain collodion, dry, cut, and detach.

With these explanations—which, I believe, are as complete as possible—every one may detach their negatives and transfer them as easily as I have done. I shall be glad if I have been able to free amateurs, when traveling, of those inconveniences and annoyances of which I have been myself so long the victim. I send with this note several detached negatives and transparent positives and some sheets of the prepared gum paper. As to the sheets of gelatine, they should be obtained in commerce and of as good quality as possible; those I have had to use leave very much to desire. A. MAGNY.

[The application of soluble commercial sheet gelatine to the film carrying the developed image requires to be received with caution, and its utility verified by experience. I used it myself some years ago, and it was communicated by me to Mr. J. R. Johnson, who, I believe, included it in one of his patents. This was also, I think, the method patented some three or four years ago under the name of "*systeme Cassan*," and used by Messrs. Provost, who exposed some very large specimens in the French photographic court, Champ de Mars: but, although the detached negatives were ingeniously suspended by the two upper corners in an upright portfolio, I noticed toward the close of the Exhibition that the image film seemed to readily abrade and separate from the surface of the gelatine. This is decidedly not the case when warm gelatine is poured upon the film of the collodion negative, for it becomes thereby as one body, or part and parcel of it. The surface application of sheet gelatine does not do this, for the collodion film is not strengthened in the least, as I can testify from my own personal experience with 3-foot negatives on which gelatine had been poured; these were dried, collodionized, and detached, and were printed as pellicle negatives, winter and summer, without any abrading or separation—in fact, were most severely tested.—W. HARRISON.]—*British Jour. of Photography.*

WIRE *vs.* TWINE BINDING FOR WHEAT.

To the Editor of the Scientific American:

NOTICING from time to time in your valuable paper, articles on "Wire in Wheat," I take the liberty of writing you on the subject; and my first remark is, Why put wire into wheat at all, to cause all this danger to the men that handle the grain, the cattle that eat the straw, machines that thrash the grain, mills that grind the wheat, and mills that make paper from the straw? And why, also, destroy land by scattering wire broadcast over it?

Thousands of farmers in the west never build a stack, but draw their thrashing machines over their fields year after year, and thrash from the shock; then burn the straw and leave the wire on the ground. It will take but a few years at most to literally cover their fields with wire to the annoyance of future operations, such as plowing, harrowing, seeding, reaping, and mowing.

Again, it takes from ten to fifteen hundred feet of wire to bind one acre of grain. No. 20 wire, such as is used to bind grain, measures about 300 feet to the pound, and costs the farmer (even with the depressed condition of the iron market) at least twelve cents a pound. Thus it costs the farmer from forty to sixty cents per acre for binding material alone.

Manufacturers of harvesters claim, and I believe justly, that two good men on a harvester will bind ten acres of grain every day; five dollars per day will pay wages and board of the two men, or, in other words, it will cost the farmer fifty cents per acre for binding grain by hand, or less than it costs for wire, besides having to purchase an expensive and often troublesome machine. When I reflect on all of these facts I wonder why it is that scientific men and newspapers should call for inventions of horse-shoe magnets, revolving cylinders, with electric batteries to demagnetize them and cause them to drop the destructive sharp pointed pieces into endless aprons to carry them out of the wheat, and also claim that there is a wide field here for invention.

What folly is this! Why call for the inventions of expensive machinery to take out of wheat a substance that should never be put into it? I venture the assertion that in less than five years binding grain with wire will be a thing of the past, and a process that no farmer in the land will tolerate, not only on account of its destructive death-dealing qualities, but also on account of its exorbitant cost, especially when the work can be done with a material that no tenable objection can be raised against, and at a good deal less than half the cost of wire. I refer now to hemp twine. Three strand hemp twine, with a tensile breaking strain of from 60 to 70 pounds, measures about 1,000 feet to the pound, and can be sold to the farmer at 16 cents per pound, with a fair margin for profit. Several different makes of twine binders are now on the market, and some of them at least are as near perfection as any of the machines binding with wire.

It is true that some objections have been raised against the use of twine as a material for binding grain, but they have invariably emanated from parties interested in the manufacture or sale of wire binding machinery, either with intent to deceive or through ignorance of the facts.

Farmers have been told again and again:

1st. That machinery could not be made that could tie a knot.

2d. That the cost of twine would be double that of wire.

3d. That the crickets or grasshoppers would eat the bands off every bundle that was bound with it.

4th. That enough twine could not be produced to supply the demand.

To the first objection, I would simply say that machines have been made, and are now on the market, that will tie knots as perfect as it is possible to do by hand.

2d. The figures given above are taken from actual weights and measurements; and as any one can calculate for himself, twine will not cost half as much as wire per acre.

3d. The theory that crickets or grasshoppers will eat the twine was long ago exploded, and no longer believed by farmers. Hemp twine is purely a vegetable substance, and there is no reason why insects will attack and destroy it any more readily when twisted into twine than when in straw in the field.

4th. The statement that twine enough could not be produced is of course a mistake, as that want, like every other, will be met so long as it can be done at a profit; nay, more, the raw material can be raised on every farm in the land if need be, and all the outlay to the farmer would be the spinning of it into twine, which can be done in any village in the country, and thus avoid the cost of transportation.

Permit me to mention one more fact. Supposing the supply of wire should run short, as was the case in the season of 1878 in many places where wire binding machinery was used. There is no help for those so unfortunate as to have such machines but to sit down and wait till wire comes from the mills, wound on spools shaped to suit the particular machine they own, their grain spoiling as they wait, while, on the other hand, twine suitable for any and all practical twine binding machines can be bought at any grocery in the country, it being a staple article

WM. MCGREGOR,
Rockford, Illinois.

[Concluded from SUPPLEMENT No. 172.]

A STUDY OF WHEAT.

By MRS. LOU REED STOWELL.

7. WE have disposed now of the woody part of the grain, and have just reached the layer of cells, which is possibly of the most interest to millers. A layer of large, nearly square cells, with very thick walls and filled with fine granular matter, see Fig. 1. The cells are 1-20 of a millimeter (1-500 of an inch) in diameter, and quite uniform in size. The cell walls are composed of several layers of cellulose, presenting somewhat of a laminated appearance under the microscope. These layers can be separated from each other quite distinctly by boiling in water for several hours or in a solution

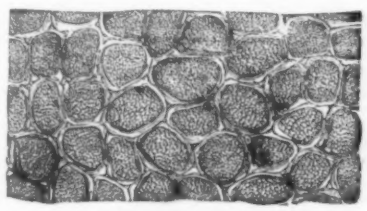


FIG. 1. OUTER LAYER OF ALBUMEN. *X* 200.

of caustic potash for a short time. The granular contents are inclosed in sacs, which are embedded in the cellular walls, as seen in Fig 3, where the two sacs have floated out of their usual resting place. These sacs contain nitrogenous substances, and contain them in much larger proportions than any other part of the grain. If any means could be employed by which the grain could be divested of all its coats excepting this last, and this last coat could be treated in such a way as to separate the nitrogenous sacs from the framework holding them, and then have the sacs form a part of the flour, we would probably have the finest and purest flour possible. The process of scientific milling has made such a great advance during the past twenty-five years, who can say but ere the next twenty-five years pass, we shall have these microscopical sacs of nutrition separated out from the woody part of the grain? The gluten, or nitrogenous substances, exist in very minute particles, about 1-600 of a millimeter (1-15000 of an inch in diameter. They are insoluble in water, alcohol, and glycerine, and are not affected by iodine or potassa. Ammonio-nitrate of silver turns them a dull yellow, while a solution of carmine turns them a bright yellow. Nitrogen is found only in cell-contents, and is never found in cell-walls.

8. Inside of the layer of albumen is found only one structure until we reach the embryo, at the base of the grain. It is composed of large, thin-walled hexagonal cells, loaded with starch, see Fig. 2. To see these cells plainly under the microscope a very thin section must be cut from the central part of the grain with a razor or a sharp knife, and then washed off carefully with a camel's-hair brush, so as to remove the grains of starch, when we find a delicate white structure resembling a honey-comb in all except color. At the center of the grain the cells are the largest, and are quite uniform in shape and size, measuring nearly 1-10 of a millimeter (1-260 of an inch) in diameter. At the surface of the

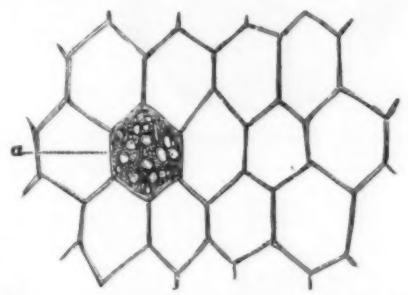


FIG. 2. HEXAGONAL CELLS FROM THE CENTRAL PART OF A GRAIN OF WHEAT. *a* SHOWS A CELL FILLED WITH STARCH GRAINS. *X* 100.

albumen the cells are quite long and narrow, and lying in such a way that they appear to radiate from the surface toward the center. The walls are delicate and nearly transparent, showing under a high magnifying power the different structures or layers of cellulose. The cells are loaded with starch grains, as seen at *a*, Fig. 2.

9. Just inside the hexagonal cells, which fill the inside of the grain, and at the same time surrounding the embryo, is found a single row of empty compressed cells, quite difficult to demonstrate.

10 The embryo occupies the lower end of the grain, and is a small oval body about one millimeter in width and two in length. The main object in life for the wheat is the production of this embryo. The development of the stem, the branching and expanding of the leaves, the whole life and history of the blossoms, are for the development of the life-germ contained within the embyro, and when this is produced the whole plant dies. The hard coats we have already described are made only to protect the starch and albumen of the center, and to give warmth to the embryo, while the starch and albumen, which are stored away in such profusion in the grain, are only formed to give nourishment to the germ while it grows. The structure of the embryo will form a study by itself, as it is very complicated, containing within itself all the parts of the new plant, which it will produce when placed under favorable circumstances.

Fig. 3 gives a diagrammatic view of the "bran" of wheat, or of all the different coats, and of the outer layer of cells containing the albumen and gluten. Any of my readers who have examined the wheat with the microscope know how difficult it is to get the first and second fruit coats apart. They almost always are seen together, as in the figure, while very generally the round cells of the albumen are seen together

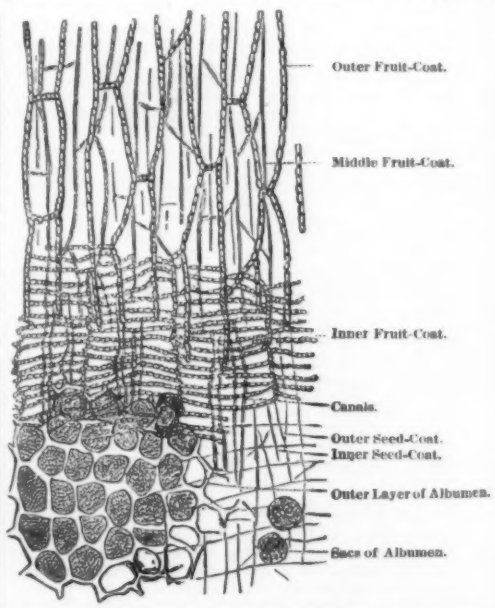


FIG. 3. SHOWING THE DIFFERENT COATS OF WHEAT.

with the different fruit coats, particularly with the inner fruit coat. When the outer fruit coat is examined with the microscope, and is in focus, the middle coat is not seen distinctly; occasionally is caught a glimpse of the beaded structure. Very frequently the three fruit-coats are together, as in the figure. Just beneath the third fruit-coat are seen the canals. The two seed coats seen just below the canals, and at the lower right-hand corner of the figure, show as distinctly as they are generally seen. Frequently there is no appearance of cell structure in either of these coats. Immediately below the two seed coats is found the outer layer of albumen, seen at the lower left-hand corner of the figure. By the openings around the edge of the layer, we see that the granular matter is contained in sacs. Two of the sacs have floated out and are seen as distinct from the coat.

In Fig 4 we have a cross section of a grain of wheat, shaved off nearly midway between the ends. At A is seen a thickening of the outer fruit coat, which is given for extra protection to the grain. At B, are seen the openings formed by the cells of the first fruit coats. They are much larger in some varieties than the cells of the second fruit coat, as seen at C. The peculiar beaded structure of the third fruit coat is seen at D. It must be remembered these cells run around the grain, while in the first and second coats the cells run lengthwise. At E are seen the two seed coats. Here again there is a slight thickening of the outer cell-walls. The masses of coloring matter are located in the outer layer of E, and are seen as little dark crystals. At F is seen the outer layer of albumen, quite large cells, arranged perpendicular to the surface. Inside of them all come the regular cells of the center, filled with starch.

The appearance of the starch under the microscope is very characteristic and peculiar. Pure white starch can be obtained by cutting through a grain of wheat and scraping with the point of the knife a little from the central part of the grain on to a glass slide. By placing a drop of water on the specimen and examining it then with a microscope we are prepared to study its appearance. There are two distinct kinds of starch grains floating in the field: Small, spherical

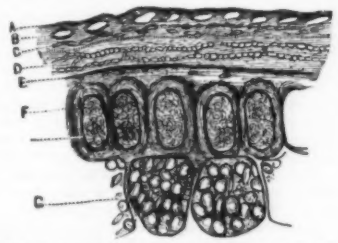


FIG. 4. CROSS SECTION OF WHEAT. DRAWN WITH CAMERA LUCIDA. *X* 200 DIAMETERS.

or angular starch grains, collecting frequently in masses, many times more numerous than the large grains, about 1-200 of a millimeter (1-5000 of an inch) in diameter. The others large lenticular grains, which, when viewed on the face, appear like a spherical body, but when viewed on the edge appear like a double-convex lens, see Fig 5. This lens shape can easily be proved by touching the cover glass gently while under the microscope with a pencil point, and watching the grains roll over in the field presenting alternately the appearance of a sphere and a lens. This simple test should always be used when working out the adulterations of any flour or spice. There is seldom any nucleus present; when it is present though, it will be found near the center of the starch grain. Still more seldom are there any rings present. According to Dr. Julius Wiesner, Professor in the University of Vienna, there is to be found still a third kind of starch grains in wheat—a compound grain found in the interior of the outer layer of albumen, and made up of from two to twenty-five individual granules. These compound grains are very seldom found in either the flour or in commercial wheat starch. Occasionally broken pieces of the compound grains are found, but these are about all the indications of a compound grain we see. They are elliptical or egg-shaped, and frequently much larger than the lenticalar grains. When subjected to dry heat the grains of wheat starch are changed very much in appearance, being warped considerably from their normal shape. They are larger, more brittle, and more transparent. However, they generally can be identified when subjected to either dry or moist heat—if the moist heat be not raised to boiling point, which would change it to a gelatinous mass. The large grains of wheat starch in their natural or normal state are very uniform in size for the same variety of wheat, but the starch grains found in the different varieties of wheat differ considerably in size. The average size is about 1-40 of a millimeter (1-1000 of an inch) in diameter. The theory of the growth and formation of these starches is of considerable interest.

Starch is the most generally diffused, excepting protoplasm, of all vegetable substance within the cell-wall. When found in the older structures, roots, stems, seeds, etc., it is found nearly pure; when found in freshly growing tissue it is in union with chlorophyl. Starch grains contain carbon, oxygen, hydrogen, and some mineral matter. They are insoluble in water, alcohol, ether, and oil, are destroyed by potassa, and colored blue or violet by iodine, the color depending on the density of the granule and the strength of the iodine. The starch grains of different families and different

FIG. 5. STARCH FROM A GRAIN OF WHEAT. *X* 375.

species of the same family differ so much in size and general appearance as to be easily identified. The largest starch grains known are those of the *tous-les-moins*, which are frequently 1-12 of a millimeter (1-300 of an inch) in diameter, while the smallest of the commercial starches are those of rice, which are occasionally 1-280 of a millimeter (1-7000 of an inch) in diameter. There are two leading theories regarding their growth. Some claim that the surface of the grain is first formed and that it grows by layers, being deposited on the inside of the case, which gradually expands until it reaches its normal size. The other and more generally accepted opinion is, that the nucleus is first formed and the grain grows by means of deposit of starchy matter around this nucleus, and each successive layer contains less moisture than the preceding layer: this explains the appearance of rings or laminæ seen occasionally in the wheat starch, but showing so plainly in the potato starch and many others. In specimens which have been subjected to even a slight degree of dry heat there appears a black line or star-shaped mark over the nucleus. The heat evaporates the moisture from the grain, and there must be a shrinkage on the surface to correspond with the evaporation. This is the greatest over the nucleus where is the greatest moisture. In very many starches there is a distinct dark cross seen when viewed with polarized light, the arms of the cross radiating from the nucleus. Some botanists claim that a cross can be seen in wheat starch, but if this be true, it is different for the starch of the different varieties of wheat. In some grains of wheat starch there is no appearance of a cross, while in some others there is a faint shadow crossing the grain while polarized light is being used.—*American Miller.*

THE CULTIVATION OF MUSHROOMS.

To go hunting for mushrooms—those plants so highly esteemed by lovers of good living—is one of the best of excuses that one can have for a pleasant country ramble. Success in gathering the dainty esculents, however, is likely to reward us only during the warmish days of September, following light and cool showers. We should start out early in the morning, at the hour when the ascending sun is about dispersing the misty vapors of the preceding night, when the drops of dew still tremble on the leaves, and hang like pearls on every blade of grass. It is then that the still button-like agaric will be found starting from the soil, and that other and more highly colored fungi will be seen dotting the ground like jewels. Later on the denizens of the insect world will have pastured on this delicious species of vegetation, and either have devoured or rendered it unfit for our use.

Providence, in creating the mushroom (a delicate attention to our wants for which we should render Him thanks), has unfortunately endowed this esculent with a very frail constitution; it grows for a very short space of time. Besides, it is to be found only at a certain season, and then only in abundance under certain conditions. To remedy the latter annoying inconveniences the gardener has brought his art to bear on the cultivation of these plants artificially, and has so well succeeded that it is now within the power of everybody to have the inexpressible joy, at any time of the year whatever, of seasoning the food of his choice with the savory cryptogam.

The cultivation of the common mushroom (*Agaricus campestris*) or "champignon" of the French, carried on in caves in the neighborhood of Paris, has arisen to gigantic proportions. The daily production is estimated at 66,000 pounds. The average price of 10 cents per pound gives 6,600 dollars as the value of the daily harvest, or $2,400,000 per annum. One cultivator at Saint-Denis employs 50 workmen and 19 horses. His daily expenses are $100 per day. His beds have a total length of 5 miles. Caves like these not only supply the wants of the city above them, but those of England and other countries also, large quantities of preserved mushrooms being exported, one house alone sending to England no less than 14,000 cans annually. Mushroom caves of another type are situated at some little distance from Paris, one of which, visited and described by Mr. Robinson, of England, may be taken as a type. This was situated at Frepillon (Méry-sur-Oise). Here are vast quarries, both for the building stone and plaster so largely used in Paris. The interior of one of these quarries, used for growing mushrooms, looks like a vast cathedral. Here in 1867 the mushroom culture was in full force, and as many as 3,000 pounds a day were sent from thence to Paris. M. Renaudot, the proprietor, had during this year the extraordinary length of over 21 miles of mushroom beds in one great quarry at Méry; and in 1869 there were 16 miles in a cave at Frepillon. Other important caves are mentioned at Moulineaux, Montrouge, and at Vitry in Picardy.

The ideas that we are about to elaborate on the subject of mushroom culture will not be addressed to the masters of the art; it is from them that we have received our lessons. We are in a position to assert, from our own experience as an amateur cultivator, that success is easily obtained, and that, too, with little expense. The conditions on which artificial culture depend seem to be exactly the opposite of those that obtain in a state of nature. We will ask, then, neither the warm rays of the sun, nor fertilizing showers, nor extensive grounds, nor even the light of day. Our equipment will be a dark place, some manure, a watering-pot, and the pale light of a cheap candle. But instead of a capricious crop, we promise an ever abundance, even during winter.

THE EDIBLE MUSHROOM (*Agaricus campestris, L.*).

The genus *Agaricus*, of which several thousand distinct species are known, many of them poisonous, contains, among other edible exceptions, *Agaricus campestris*, or "mushroom" *par excellence*, which has been specially chosen for artificial cultivation, on account of the facility with which it may be grown. In the first place it will be well to obtain some knowledge of its botanical character, as it may help us direct its culture.

If we place before us one of these plants, very entire, and carefully removed from the soil, we observe at the base of the stem a network of pale filaments which spread through the soil horizontally. In the language of gardeners this is called the "spawn;" in that of science, it is known as the *Mycelium*. When these interlacing filaments (which, collectively are the analogues of the root, stem, and leaves of flowering plants) are placed in situations unfavorable to their further development, they become abnormally compacted into a solid mass which remains sterile, and which at one time was regarded as constituting a perfect fungus to which was given the generic name of *sclerotium*. When the spawn refuses to develop, gardeners say that it does not "run." We will point out a means of preventing such an accident further on.

From this spawn, which always grows and spreads beneath the soil, spring immense numbers of little round tubercles, which quickly increase in size and rapidly succeed each other. These little bodies push themselves above the soil and soon assume the form that we recognize as a mushroom. The plant in its fully developed state consists of three parts: the *stipe*, or stem, the *pileus*, or cap, the *lamellæ*, or gills. The stipe is often somewhat swollen at the base, and its flesh is white. A longitudinal section shows that it is not hollow or tubular, as in some species of agarics, but continues to the center, although less firm than near the circumference. Its tissues dilate at its upper extremity and form a round, fleshy, convex *pileus* or cap, which ultimately becomes almost flat in the center, but not depressed. To the concave under side of the cap are attached numerous plates, growing side by side, and radiating from the stem toward the circumference of the cap. These plates, which are of a rosy color in the first stages of the plant and which afterward become purplish brown, are the *lamellæ* or "gills." When the plant is very young a delicate white membrane covers the gills, stretching from the stem to the edges of the cap. This membrane is called the "veil." As the plant expands the veil ruptures at the edges of the cap and remains hanging flaccidly around the stem, constituting then what is known as the *annulus* or "ring." Besides this partial veil that hides the gills there is another one called the *volva*, which, beginning at the base of the stipe, envelops the whole fungus at first, just as the shell incloses within it all the elements of the egg. In the common mushroom, however, the texture of this volva is so delicate that it completely disappears in the primary evolution of the plant.

If we make a thin transverse section of one of the gills when mature (that is, when it has assumed its purplish brown color, and place it on a slide and examine it with the microscope, we very easily perceive that it is made up of three distinct layers of cells; a middle layer called the *trama*, composed of elongated cells continuous with those of the cap, and two lateral layers formed of smaller ones, and forming the gill surface. From the latter again arise millions of closely packed elongated-club-shaped bodies, each terminated by four spicules. At the apex of each spicule is a small ellipsoidal cell called a *spore*. If we place the cap of a mature mushroom, gills downward, on a sheet of white paper, the paper will be found covered after a short time with a number of radiating, brown, powdery lines, corresponding with the gills. These lines are due to the spores which have fallen from the gills. The spores are the reproductive organs of the plant, and analogous to the seeds of other plants—although they are not *seeds* in any sense whatever. They contain no germ, or embryo of a future plant, and the method by which they reproduce their like is entirely different from that which obtains among flowering plants. Usually, mushrooms are cultivated by means of spawn, which is kept on hand by dealers in seeds. By these it is sold in the form of what are called "bricks," differing in shape with different makers, but generally thinner and wider than common building bricks. The assertion has been made by eminent botanists that mushroom spores cannot be made to germinate until they have passed through the body of a horse and been ejected in his dung. This statement, however, is not borne out by facts, for in France many country gardeners procure fresh crops of the fungus by watering their mushroom beds of a preceding season with water in which ripe mushrooms have been macerated. However, these are the only two methods of culture; transplanting the small plants does not prove successful.

METHOD OF OBTAINING MUSHROOM SPAWN.

In districts where the agaric grows in abundance, the millions of spores detached from each gill are dispersed by the winds over a great extent of country, or are disseminated by the rains, which carry them along. Many meet with spots favorable to their development. When this is the case (which happens when they alight in nitrogenous matters in a state of decomposition) and they are favored by the proper atmospheric conditions, they throw out from their extremities pale branching threads; and, by the anastomosing of numbers of these, proceeding from various spores, arises the felted mass called the spawn, which we have already noticed. Very often the deeper layers of farm dung heaps (those that have been neither too much warmed nor moistened) are completely permeated by this felted tissue, and covered with a powdery matter. This spawn, gathered and dried, may be kept as long as fourteen years. But if it is left exposed to the air, light, and moisture, it rots, dies, and disappears.

By the observation of such facts as these we have succeeded in taking nature unawares and applying her secret processes to our great profit. It is only necessary, then, to group these conditions, in order to reproduce at our will, at any given time, and in a regular way, that *Mycelium* which, to a superficial observer, appears to be an accidental and variable production.

From April to September we open, at the foot of a wall (with an eastern exposure for cool weather, and with a western during summer) a trench 20 inches deep and 2 feet wide. The length is to be determined by the importance that we wish to give to the development of mushroom culture.

In the first place, a sufficient quantity of horse droppings having been mixed with a quarter of its bulk of cut straw, is put in a heap and allowed to stand until it parts with its first heat. A supply of wheat hulls (preferably those from a winnowing machine), are also to be procured and held in reserve.

First we line the bottom of the trench with a layer 6 in. thick of hulls, then a layer of manure of the same thickness, press the whole down firmly with the feet, and moisten it moderately with ordinary water, or, better still, with water in which mature mushrooms have been macerated. We continue thus, putting on successive layers of water and dung, until the whole mass comes above the level of the soil. We finish by fashioning the upper part into a ridge shelving off on both sides, and covering it with a layer of good soil or rubbish, 6 inches think. Finally, there must be spread over the whole a good covering of horse-litter, in cases where it is feared that the sun will shine too hotly, or that a season of rain may induce fermentation through too much moisture. A bed prepared in September should be inspected in December. For this purpose we make an opening on one of the sides, or at one of the ends of the ridge. The spawn has reached the proper point if it show bluish, spongy filaments, and exhibits a strong mushroomy odor. If its formation seems to be incomplete we can wait a month, without inconvenience, because the growth of mushrooms is not to be expected during this season. The bed is opened in January or February, at the latest. The finest portions of the spawn having been selected we leave the rest, especially that which exhibits a dark brown color due to a too far advanced decomposition. To hasten the drying of the cakes of spawn, they are separated into masses weighing from one to two ounces and kept in a dry and well aired coach house or barn. Thus prepared, and dried in the air and shade, the spawn will keep for a long time, and always be ready for use. The wheat hulls may be replaced by straw cut very short, or by beds stratified in the following manner: 3 inches of hens' or pigeons' dung and 5 inches of horse droppings, prepared as we have explained. In spite of the aid of the wind in distributing the spores of the agaric over an unlimited space, whatever be the prodigious fecundity of the species and the astonishing resources of nature, so simple a means of procuring mushrooms as gathering their seeds at hazard, can give good results only in districts where this esculent is cultivated in abundance or grows naturally. Elsewhere, it is expedient to buy the spawn, the transportation and preservation of which present no inconvenience.

PREPARATION OF MATERIALS.

The places in which mushrooms can be readily and pro-

fitably grown are various: 1. In the mushroom-house proper. 2. In sheds, cellars, outhouses, stables, coach-houses, railway arches, etc. 3. In deep caves and quarries, like those of Paris, before spoken off. 4. In the open air, in gardens or fields, on prepared beds. 5. In gardens, among various crops, without any preparation beyond inserting the spawn. 6. In pastures where the mushroom is not already established. To these might be added another group, illustrated by the case of a Belgian cook who grew a dish of mushrooms in a pair of old wooden shoes. It is of the utmost importance, however, in selecting a situation upon which to form and make mushroom beds, that a moderately warm place, having a dry bottom, should be secured. As a general thing, a more or less confined space is far preferable to an open shed, or outhouse, or any other situation of this kind that is in direct communication with the external atmosphere, the successful culture of the plants depending on an equable temperature, and that of about 60° Fahr.

Whatever be the spot chosen, the preparation of the bed, and the materials which compose it are the same. The care bestowed on the culture differs only in secondary details. The quality of the manure is one of the bases of success. The worst is that of horned cattle, because it is too watery and too cold. The best is that of horses that are fed on dry nitrogenous food, and where litter well impregnated with dejections is rich in ammonia and phosphates. In this case the dung is dry, and its quality greatly favors fermentation. The quantity of droppings judged necessary are placed in a pile and allowed to remain for three or four days, so that it may part with its superfluous heat. It is necessary to avoid too great an amount of heat, which merely burns up, and too much cold, which only retards the vegetation.

For this reason the manure, already held in reserve, is again taken, shaken up, mixed, and placed in a heap about 30 inces high, and three or four times as broad, moistening from a watering-pot with a fine rose all those parts that are too dry, and pressing the pile down as it is being built up. Care should be taken to reject all foreign bodies, especially nails and other pieces of iron, as well as matter in a state of decomposition. The spawn, during the process of growth, had a decided aversion to decayed, rotting materials, or to any other substances in a decomposing condition, and it will not grow, thrive, or prosper in contact with such materials. At the end of a week the pile is again entirely worked over, being distributed with a pitchfork and watered according to its needs so that all parts are evenly moistened. A second pile is then made, about 3 feet high, care being taken to place in its center those portions of the manure that formed the exterior of the first pile. Less than a week after the operation is repeated for a third time. Such is the general rule. But there is nothing absolute about it, as it can be modified according to atmospheric conditions and the nature of the manure.

HOW TO MAKE THE BEDS.

Before making up a mushroom bed, regard should be had to the following considerations: First, as to the thickness that will be necessary to insure a prolific and durable bed. And, secondly, as to the quantity of materials in a loose or open condition that will be required to insure such a thickness. The former will vary according to the position in which the bed is to be made; but, if it is made upon shelves in an old bin, or in close proximity to hot water pipes, or flues, it should not be less than from 18 inches to 2 feet in thickness, when well beaten down. Should the beds, however, be formed on the floor of a cellar or shed, or other similar situation, a thickness of about one foot will be ample to secure the requirements of the case. The more moderate in size the beds the better; and there will be less risk to contend against of too frequent and uncertain fluctuations of temperature than with large beds, and especially in the hands of amateurs and of others whose experience is not very large.

TRUE MUSHROOM (*Agaricus campestris*).

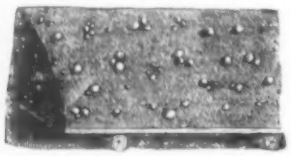
Assuming that the position and space are fixed upon, and the materials are at hand, the first thing to be done is to form a basis on which the future bed is to rest, by placing a moderate layer of coarse street litter evenly over the bottom. The materials should then be tossed lightly and evenly over this layer, until it attains to a thickness rather more than double that that it is required to be when finally finished off. It should be pressed down with the feet uniformly, and allowed to remain so until it has again become fairly heated. It should be induced to heat to as high a degree as possible, and when this is attained and the temperature has declined to about 140°, the bed should be firmly beaten down forthwith. This is best done by treading it well down all around with the feet, if the position of the bed will allow of it. Then proceed to ram the whole surface down vigorously, with a heavy flat-bottomed rammer; until no further impression can be made upon it; leaving it as before to recover a little heat. Should the latter be slow in redeveloping, mats or some other suitable material should be laid over the beds to assist in raising the temperature.

PLANTING THE SPAWN.

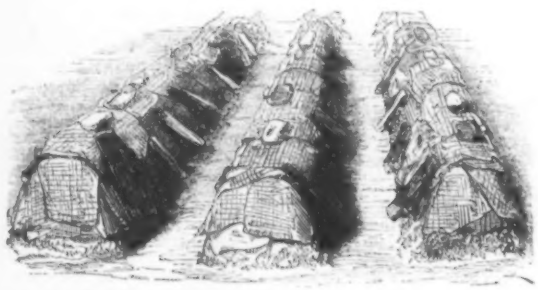
When a somewhat stationary temperature, averaging from 85° to 90°, has been gained, proceed to make holes in the surface of the bed with a thick, blunt dibble. They should be about two inches deep and from four to six inches apart. It will be found advisable now to leave the bed for a night or two, to ascertain its range of temperature definitely, and should it rise to a mean of 90° it should be left until it falls to the temperature above indicated. As soon as the bed is beaten down the spawn should be broken into pieces about the size of a hen's egg, and a piece placed in each of the previously prepared holes. Each piece should be pressed down as firmly as possible without breaking it, and at the same time the materials should be drawn firmly around it. When "bricks" are used they should be placed in tepid water for four or five minutes, and afterward laid loosely on the surface of the bed until the required temperature of the latter is proper for "spawning." The bed after having been again trodden over will be ready for "soiling," as gardeners term it. The best soil for this purpose is a stiff yellow loam of moderate consistence; but whatever the soil, it should be tolerably dry. Spread it nicely and evenly over the bed, and if this is required to produce mushrooms quickly, say in six weeks, from three-quarters to one inch will suffice. The soil should be again trodden down firmly and beaten over with the rammer, and then patted down well with the back of a spade. While performing the latter operation the surface should be sprinkled all over with water, and there should be a pail or water-can of clear water at hand wherein to dip the spade occasionally, and thus to give the bed the final "pat" over; this will cause the whole surface to amalgamate and set firmly together as one mass. When the beds are made in the open ground, or other similar situations, it will only be necessary to follow the instructions given above, and to act within the limits described, as being applicable to more favorable situations.

WHAT ADDITIONAL CARE IS NECESSARY.

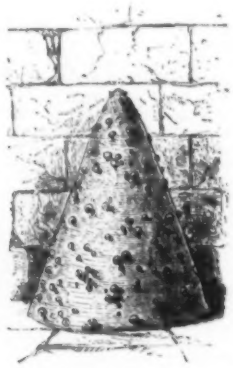
From the time of spawning the beds until the mushrooms begin to "show," which will be at the end of forty days, the only attention they require is to keep them dry, warm, and snug. As the materials of mushroom beds are generally moist, and as but little evaporation can take place in structures where they are usually grown, water is rarely necessary, and should not be applied until the surface of bed and soil are really dry. It should then be given copiously enough to well moisten the bed, and it should be soft water heated to 80° given with a fine rose, and steadily and patiently applied equably over the entire surface of the



MUSHROOM BED ON SHELF AGAINST CELLAR WALL.

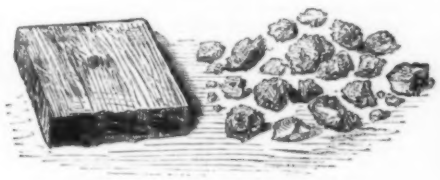


MUSHROOM BEDS IN MARKET GARDEN.



PYRAMIDAL BED ON CELLAR FLOOR.

MUSHROOM BED IN BOTTOM OF AN OLD CASK.



"BRICK" MUSHROOM SPAWN.

MUSHROOM CAVE, 70 FEET UNDERGROUND, AT MONTROUGE, NEAR PARIS.

MUSHROOM CULTURE ON SHELVES IN STABLE.

bed. If one drenching is not sufficient to moisten it properly, another should be given. In watering, the French use the following:

Nitrate of ammonia	35 grains.
Saltpeter	8 "
Hydrochlorate ammonia	4 "
Water	1 gallon.

When once the crop begins to fairly show above ground, a moderate soaking should be given to the whole bed, and with water always a few degrees higher than the temperature of the house. From this time the bed may be considered as in "full bearing," and in structures to which artificial heat is applied, the beds should be sprinkled over with a fine syringe every evening. Most beds are apt to yield successional crops, and a few will also sprout up at intervals between the main growths, and demand some notice. As a rule, a nice watering should be given after each bearing has been secured; and if after two good crops have been obtained in this way, a little clear liquid manure, to which are added two ounces of salt to every gallon, is applied, it will materially revive the declining fertility of the beds. Another good mixture for the latter purpose is one ounce of guano added to a gallon of water.

CULTURE IN CELLARS.

As we have before said, mushrooms may be cultivated almost anywhere: in cellars, excavations, under a stairway, in stables, etc., provided that the beds, having been prepared according to our method, the following conditions are observed: An equable temperature ranging between 60° and 70° F.; no strong currents of air, and no sudden change of temperature. The more heat the quicker and more abundant the crop. A mistaken idea exists among the cultivators of mushrooms in regard to the admission of light into the structures where they are grown, and it is often stated that "they grow only in the dark." But if darkness does cause actual enlargement in process of growth, it should be borne in mind that light, and light alone, is capable of enabling them to attain to their full development.

Every day we have occasion to admire the fertile resources of nature, who manufactures out of very simple materials—three or four elements that she knew how to combine—the various matters that form the world's strata; as well as the more subtile substances that dazzle the sight or impress and exalt the senses of smell and taste. But here is something more extraordinary. Nature creates strength out of weakness. The mushroom, in order to push its cap out of the soil, breaks through, with but a spongy tool, the hardest terrestrial crust. A single mushroom has been seen to loosen and raise in one night a flagstone weighing over one hundred pounds.

A correspondent of the *Gardener's Chronicle* says: "I observed a few days ago in our mushroom house, with considerable interest and surprise, the penetrating power of mushroom spawn. One side of the bed is of brick, 4½ inches thick, firmly set in hard lime, so close in the texture that it is impossible to introduce the point of a nail without considerable force. Nevertheless, the mycelium found admission and produced mushrooms of a considerable size on the outer side. The wall in several places contained porous bricks, and there, too, the mycelium found its way right through." And yet the soft, fragile, lever which accomplished these feats in incapable of opposing the least resistance to the pressure of a finger; and the step of a child would crush this Hercules.

Stables and like structures offer capital positions in which successful mushroom culture may be carried on with ease. Place an old cupboard in some unused corner of the stable, and space its shelves so that they shall be 12 inches apart, and shroud them with canvas curtains. So much for the habitat. Prepare the manure in the usual manner and put it in layers 8 inches deep on the shelves. Pieces of spawn are then lightly buried in the manure at distances of 5 inches apart. The beds are then beaten down with the back of a spade, and a few days afterwards covered with a mixture composed of

Loam	60 parts.
Powdered plaster	40 "
Nitrate potash	½ "

The beds are watered as often as they require it. Two months afterwards the mushrooms will spring up in abundance. In cultivating mushrooms in cellars, preference should be given to a warm, dry one; and it should be exposed to no draughts. Beds can be made in cellars in many ways. Those made in the middle should always be formed with two sides, while those against the walls should be only half as thick, on account of their having one useful side. It is also possible to arrange them on shelves, one above another. For this purpose strong bars of iron are driven into the wall, upon which are placed shelves of the proper size covered with earth, upon which is formed a bed as before described. Beds may even be made on the bottom of casks, which should be at least 2½ feet in diameter; they may also be built up in the shape of a sugar loaf, about three feet high, and the pieces of spawn placed an inch and a quarter deep and sixteen inches apart.

CULTURE IN THE OPEN AIR

in gardens may be carried on with great ease. Abundant crops are grown by market gardeners of London and Paris in such situations. The culture is never attempted by them in summer, but is carried on in full vigor in winter in the open air. No care is taken in the preparation of the manure by the London gardeners; it is usually made into beds soon after it is brought home and before it is allowed to heat, and then the beds are made in the form of potato-pits and beaten firm. The beds are spawned when at a temperature of about 80° F., the pieces of spawn being placed about a foot or so apart, and it is then immediately earthed, ordinary soil being used, and the bed covered to a thickness of a couple of inches. Beds made in this way in the autumn and winter months, and covered with a thick layer of litter and mats, seldom require any watering.

Wherever the cultivation of cucumbers or melons in pits or frames is carried out, nothing can be easier than to grow large crops of mushrooms after the melons, etc., are cleared away. The spawn may be inserted over the surface of the little mounds usually made for the reception of the young melon plants, and also over the remaining surface of the beds which are generally covered with a few inches of earth. After the melons have done bearing and the haulm is cleared away, the spawn will usually be found to have spread through the deep mass of earth in the beds. As little or no water is given or required while the melons are ripening, a good soaking of tepid water will generally be necessary to encourage the mushrooms into profuse bearing. If the season and situation be mild and warm, the lights may be taken off, and if the sun be very strong, the bed may be shaded with canvas or mats. If the season be late and cold, it will, on the other hand, be desirable to keep the lights on, and even to cover them in cold weather.

GATHERING THE CROP.

As we have said before, mushrooms have the power of reproduction by spores, as flowering-plants have by seeds; hence we may remark that they should always be gathered, at the very latest, as soon as they are full grown, although it is better to pick them much before maturity. It is natural to infer that, by leaving them in the bed a day or two beyond their perfected state, the spawn is considerably weakened. Where they are cultivated on a large scale the gathering should take place very frequently; where there are several beds in bearing, the mushrooms should be gathered every morning. In all cases they should be pulled or twisted off bodily, the foot-stalk attached; never cut out, so as to leave decaying stumps in the bed. The holes left after pulling them out should be filled with a little fine loam, kept on hand for that purpose.

THE CULTURE OF OTHER SPECIES.

Should some attention be paid to the cultivation of our other species of edible toadstools, by observing the conditions under which they are reproduced, the number of our esculents of this kind might be greatly increased. But as regards fungi, the public does not show itself very desirous of novelties. It has given its preference to one of the most delicate and digestible of the toadstool family, and seems willing to hold on to that.

The private culturist, however, may vary his pleasures. In the south of France the "attenuated agaric" (*Agaricus cylindraceus*, D.C.) is cultivated. It grows naturally at the foot of poplars and on the trunks of willows. To reproduce it, round slices, 1 to ½ inch thick, of poplar are buried just beneath the surface of the earth, in moist, open places. In spring the upper surface of the wood is rubbed over with the gills of the agaric, and towards autumn a full crop is obtained.

Auguste Saint-Hilaire says, in regard to *Agaricus Aegerita* (called *Pivoulade* by the Languedocians), that it can be cultivated and had during the whole year. It is merely necessary to cover poplar cuttings with earth, and water them from time to time to accelerate vegetation.

Another agaric is obtained from the pollard head of the black poplar. Dr. Badham says that it is usual to remove these heads at the latter end of autumn, as soon as the vintage is over and their marriage with the vine is annulled; they are abundantly watered during the first month, and in a short time produce that truly delicious fungus, the "changeable pholiota" (*Agaricus mutabilis*), which, during the autumn of the year, makes the greatest show in the Italian market places. These pollard trunks continue to bear for from twelve to fourteen years. This species of agaric is also common to the United States.

Finally, we are told by Father Cibot that the Chinese obtain several species of fungi merely by placing bits of poplar, elm, chestnut, or mulberry bark, in good soil, with a proper exposure. Those fungi that are in most extensive use as food, contain, in addition to some saccharine or earthy matter, the following proportions of nitrogen in 100 parts of the dried plant:

Common mushroom (*Agaricus campestris*)	7·26
Delicious agaric (*Lactarius deliciosus*)	4·68
Edible russula (*Russula vesca*)	4·25
Chantarelle (*Cantharellus cibarius*)	3·22

In cultivation, the mushroom is not so rich in nitrogen, the quantity of this element rarely exceeding four per cent.

MUSHROOMS IN RUSSIA.

In Russia, as soon as the summer is merging into autumn, and the first heavy rains moisten the mossy ground, and draw the damp earthy fragrance into the air, then out of the teeming sod rise the mushrooms of different shapes, sizes, and color.

Every little child in Russia learns from its earliest years the difference between good edible mushrooms and poisonous fungi; nay, the child of six or seven years will tell you whether those he has found are the best for cooking fresh, for drying on strings, or for salting down in casks, and one never hears of a Russian being ill and dying from eating toadstools or other injurious fungi, although he eats more mushrooms in a week than an Englishman would like to eat in a year.

In Russia we have the *Champignon*, about the only acknowledged mushroom in England; the *Biclo-grip*, or white mushroom; the *Berissovoy*, or birch mushroom, sometimes termed the "bun mushroom" here; the *Krasnoi-grip*, or red mushroom; the *Maslinik*, or butter mushroom; the *Sarayaska*, and one or two kinds which are considered inferior to those we have mentioned, and are prepared for use by salting.

But we can hardly close our list of fungi without mentioning the king of the toadstools, a beautiful poisonous fungus that rejoices in the name of the *Mooha-mor*, or fly-death (*Agaricus muscarius*), because of its employment, when stewed with treacle, for attracting and killing flies; it is a very handsome toadstool, and can be seen a long way off, for it has a tall, straight stem and a crown like a little, round table, of a bright crimson color, dotted with white spots and blotches.

Russia abounds in mushrooms, and as they form an important article of food, both dried and salted, among the people in the winter, they are eagerly sought for and carefully preserved.

Many English cottagers might learn a lesson of economy, and of how to make the best use of God's gifts, from the careful home management and the capacity displayed by the Russian peasantry.

MUSHROOM CULTIVATION IN JAPAN.

In pursuance of a plan commenced a short time back of furnishing information respecting the staple products of Japan, their culture or preparation, Her Majesty's Consul at Yokohama, in his published report to the Foreign Office, deals, among other matters, with the cultivation, etc., of mushrooms; and as that subject is a novel one in this country, some brief account of the process may not be unacceptable to our readers. The best of the edible species of mushrooms are known to the Japanese as *matsu-take* and *shū-take*. The difficulties experienced in preserving the former kind prevent their being available for export, added to which, even when successfully dried, they are nearly tasteless; the *shū-take*, on the other hand, have this peculiar excellence, that though they are all but tasteless in their raw state, they have an extremely fine flavor when they are dried. The quantity that grows naturally on the decayed roots or cut stumps of the *shū* tree is not sufficient to meet the demand, and, consequently, much skill has been brought to bear on their cultivation, notably by cutting off the trunks of the *shū* and other trees, and forcing the growth of the mushrooms on them. Different varieties of oak are most in favor with the Japanese for the cultivation of mushrooms, the one just mentioned being considered to give the best results. The tree grows abundantly in warm places, with a southeasterly aspect, and attains a height of about 18 or 19 feet. It is an evergreen, bearing small acorns, which are steamed and eaten. The wood is used for making boats' oars, charcoal, etc. Another oak, *kashiwa*, from which mushrooms are made, is also plentiful in warm localities, and grows to a height of 30 or 40 feet. Its leaves are used in cookery, and the wood is in great demand for divining sticks. A third description of oak, the *donguri*, is found all over the country, and its acorns, after being pounded and steeped in water, are made into dumplings. Mushrooms, we are told, are obtained from any of the above-mentioned trees in the following manner: About the beginning of autumn a trunk 5 or 6 inches in diameter is selected, and cut up into lengths of 4 or 5 feet; each log is then split into four pieces, and on the outer bark slight incisions are made at once with a hatchet, or else the logs are left till the following spring, when deep cuts are made in them. Assuming the former course to have been pursued, the logs, after having received several slight incisions, are placed in a wood where they can get the full benefit of the air and heat, and in about three years they will have become tolerably rotten in parts. After the more rotten parts have been removed they are placed in a slanting position, and about the middle of the ensuing spring the mushrooms will come forth in abundance. After these have been gathered the logs are still kept, and submitted to the following process: Every morning they are steeped in water, and in the afternoon they are taken out and beaten with a mallet; they are then ranged on end in the same slanting position as before; and in two or three days' time mushrooms will again make their appearance. In some places it is the custom to beat the logs so heavily that the wood swells, and this seems to induce the growth of mushrooms of more than ordinary large size. If, however, the logs are beaten gently, a great number of small mushrooms grow up in succession. Another mode of forcing the growth of mushrooms is to bury the cut logs at once in the earth, and, after the lapse of a year, to take them out and treat them in the manner just described. The mushrooms thus grown are stored in a barn on shelves ranged along three sides, with braziers lighted underneath. Afterward they are put into small boxes, the bottoms of which are lined with either straw or bamboo mats; these are placed on the shelves, and gradually dried with great care. Another mode of drying mushrooms is to string them on thin slips of bamboo, which are piled together near the brazier, the heat being kept in by inverting a closely-woven basket over them. Of other edible mushrooms in Japan besides the *shū-take*, Mr. Robertson particularizes the following: The *kikurage*, which grows in spring, summer, and autumn, on the mulberry, the willow, and other trees; it is a small, thin, and soft mushroom, very much marked at the edge, and of a brownish tinge. The *iwa-take*, which grows on rocks in thick masses. The *so-take*, a very delicately-flavored mushroom, which is found on precipitous crags, and is consequently scarce, owing to the difficulties attendant upon its collection. The *kawa-take*, a funnel-shaped mushroom with a long hollow stalk, which is found in shady spots on moorland.

SIR J. LUBBOCK ON ANTS.

SIR JOHN LUBBOCK read two papers on ants before the Linnæan Society lately. The first gave an account of their anatomy, but from the extreme complexity of these interesting little creatures it would be impossible to make their communications intelligible without the figures. The second paper was a continuation of his observations on the habits of ants. He observed that he had at first isolated his nests by means of water. This was effectual enough, but, especially in summer, the water required to be continually renewed. Kerner, however, had suggested that the hairs of plants served to prevent ants from obtaining access to the honey, and it accordingly occurred to him that strips of fur arranged with the points of the hairs downward might answer his purpose. He had tried this, and, finding it successful, he thought a similar arrangement might perhaps be found useful in hot countries.

It is generally stated that the queen ants alone lay eggs, but Sir John has found that in most of his nests some few of the workers are capable of doing so. It appears, however, that these eggs always produce males. In the case of bees we know that the queen is fed on a special kind of food. In ants it is not feasible to make observations similar to those by which in bees this has been established. It is, however, rendered more than probable by the fact that, while males and workers have been bred by hundreds in his nests, no queen has yet been produced.

M. Lespès has given a short but interesting account of some experiments made by him on the relations existing between ants and their domestic animals, from which it might be inferred that even within the limits of a single species some communities are more advanced than others. He found that specimens of the curious blind beetle claviger, which always occurs with ants, when transferred from a nest of lasius niger to another which kept none of these domestic beetles, were invariably attacked and eaten. From this he infers that the intelligence necessary to keep clavigers is not co-extensive with the species, but belongs only to certain communities and races, which, so to say, are more advanced in civilization than the rest of the species. Sir John Lubbock, however, removed specimens of the curious blind platyartherus from one nest to another, but they were always amicably received. He even transferred specimens from a nest of lasius flavus to one of formica fusca, with the same result.

As regards the longevity of ants, he has now two queens of formica fusca, which seem quite in good health, and which have lived with him since 1874; they are, therefore, probably five years old. He has also workers of lasius niger, formica sanguinea, formica fusca, and formica cinerea, which he has had under observation since 1875.

In his previous papers he has given various instances which seem to show that ants do not exhibit such unvarying kindness to their friends as has been usually supposed. He wished, however, to guard himself against being supposed to question the general good qualities of his favorites. In fact, ants of the same nest never quarrel among themselves; he had never seen any evidence of ill-temper in any of his nests. All is harmony.

He had already in previous papers given various instances of tender kindness. Again, in one of his nests of formica fusca was a poor ant which had come into the world with-

out antennæ. Never having previously met with such a case, he watched her with great interest, but she never appeared to leave the nest. At length, one day he found her wandering about in an aimless sort of manner, and apparently not knowing her way at all. After a while she fell in with some specimens of lasius flavus, who directly attacked her. He then set himself to separate them; but she was evidently much wounded, and lay helpless on the ground. After some time another formica fusca from her nest came by. She examined the poor sufferer carefully, then picked her up tenderly and carried her away into the nest. It would have been difficult, Sir John thinks, for any one who witnessed this scene to have denied to this ant the possession of human feelings. It is clear, from the experiments recorded in the present and in Sir John's former papers, that the ants recognize all their fellows in the same nest, but it is very difficult to understand how this can be effected. The nests vary very much in size, but in some species 100,000 individuals may probably be by no means an unusual number, and in some instances even this is largely exceeded. Now, it seems almost incredible that in such cases every ant knows every other one by sight; neither does it seem possible that all the ants in each nest should be characterized from those of other nests by any peculiarity. It has been suggested in the case of bees that each nest might have some sign or password. The whole subject is full of difficulty.

It occurred to Sir John, however, that experiments with pupæ might throw some light on the subject. Although the ants of every nest, say of formica fusca, are deadly enemies to others, still, if larvæ or pupæ from one nest are transferred to another, they are kindly received, and tended with, apparently, as much care as if they really belonged to the nest.

In ant warfare, though sex is no protection, the young are spared—at least, when they belong to the same species. Moreover, though the habits and dispositions of ants are greatly changed if they are taken away from their nest and kept in solitary confinement or only with a few friends, still in such circumstances they will carefully tend any young which may be confided to them. Now, if the recognition were effected by means of some signal or password, then, as it can hardly be supposed that the larvæ or pupæ would be sufficiently intelligent to appreciate, still less to remember it, the pupæ which were intrusted to ants from another's nest would have the password, if any, of that nest, and not of the one from which they had been taken. Hence, if the recognition were effected by some password or sign with the antennæ, they would be amicably received in the nest from which their nurses had been taken, but not in their own. He therefore took a number of pupæ out of some of his nests of formica fusca and lasius niger and put them in small glasses, some with ants from their own nest, some with ants of another nest of the same species. The results were that 32 ants belonging to formica fusca and lasius niger, removed from their nest as pupæ, attended by friends and restored to their own nest, were all amicably received. What is still more remarkable, of 22 ants belonging to formica fusca, removed as pupæ, attended by strangers, and returned to their own nest, 20 were amicably received. As regards one, Sir John was doubtful; the last was crippled on coming out of the pupa case, and to this, perhaps, her unfriendly reception may have been due.

Of the same number of lasius niger, developed in the same manner, from pupæ tended by strangers belonging to the same species, and then returned into their own nest, 17 were amicably received; three were attacked; about two Sir John felt doubtful. On the other hand, 15 specimens belonging to the same two species, removed as pupæ, tended by strangers belonging to the same species, and then put into the strangers' nest, were all attacked. The results may be summarized as follows: Pupæ brought up by friends and replaced in their own nest—attacked, 0; received amicably, 33. Pupæ brought up by strangers and put in own nest—attacked, 7 (about three of these Sir John did not feel sure); received amicably, 37. Pupæ brought up by strangers and put in strangers' nest—attacked, 15; received amicably, 0. Sir John intends to make further experiments in this direction, but the above results seem very interesting. They appear to indicate that ants of the same nest do not recognize one another by any password. On the other hand, if ants are removed from a nest in the pupa state, tended by strangers, and then restored, some at least of their relatives are certainly puzzled, and in many cases doubt their claim to consanguinity. Strangers in the same circumstances would be immediately attacked. These ants, on the contrary, were in every case, sometimes, however, after examination, amicably received by the majority of the colony, and it was often several hours before they came across one who did not recognize them.

THE STURGEON.

THE great Caspian Sea and its tributaries are the center of vast inland fisheries, whose immense value and peculiar products have made the inland fisheries of Russia famous throughout the world. The sturgeon, a fish almost despised among American fishermen, and almost wholly neglected in other nations, is the most important of the many species of fish captured by Russian fishers.

Many species, from the huge "belouga" to the small but delicious and far-famed "sterlet" are met with, and in the latest and most reliable accounts of the yearly product of those fisheries, over 41,193,000 pounds of sturgeon flesh, isinglass, "vesiga," and caviar, valued at nearly four millions and a half of dollars, are the average yearly returns from this curious and with us under-valued fish.

Vast seines, which sweep the deep pools of the wide shallow rivers; great stationary nets stretched on piles, or made in the form of a large bag distended by wooden hoops, into which the doomed fish enter, but cannot recede; floating nets, buoyed and loaded, having meshes of from two and a half to six inches in mesh, and of varying strength and thickness of cord; and huge "pounds" or weirs, of great extent, strength, and cost, lay the open sea, the shallow bays, and the broad shallow rivers of Southern Russia under contribution to supply the peculiar commodities for which she has been famed for generations.

But there are other means of taking the sturgeon not dependent on subtle labyrinths or tangling meshes of deftly woven cordage. The "palangre" or bottomline is a terrible contrivance, being a small rope floated near the bottom of the sea to which, at short intervals of a foot or less, are fastened hooks of medium size at the ends of pieces of whipcord not over a foot in length. These hooks are very sharp and unbaited, and as the sturgeons, as is their habit, go stirring up the mud of the bottom, they are often caught by one of the fatal fringe of steel barbs, and in their struggles are sure to hopelessly entangle and drown themselves.

ARMIES OF FISHERMEN.

The "belouga," the largest species in the Caspian, is also caught on set lines of half-inch rope, which have attached large hooks ganged with pieces of whipcord nearly two fathoms long. The bait used is a small living fish of the so-called "herring" species, which are kept alive in wells for the purpose. In the winter they are caught through the ice by long lines and large hooks baited with seal's fat. Only one-half of the line, which is about thirty or forty fathoms long, is allowed to run out, the center being made fast to a wooden toggle by thin thread; to this toggle also the end of the line is secured. When the sturgeon bites the thread is broken and the fish runs off gorging the bait, until suddenly brought up by the toggle. Many are also taken through the ice by an automatic arrangement, consisting of a heavy pole mounted on a tripod of wood in such a way that its heavy lower end will out-balance the heaviest "belouga;" the line and hook are passed through a hole in the ice, and the small end of the pole being brought down by main strength, the line is made fast at the right depth by a pin set in a framework of osiers which forms an arch above the hole. When the fish bites the pin is pulled out, the heavy end of the pole falls, and the fish is hauled out to drop helpless upon the ice or dangle struggling and quivering above the aperture.

Camps of Cossacks, who watch from one hundred to one thousand of these ingenious traps, may be met with among the Ural Cossacks in winter, and in other sections these semi-barbarians meet on given days, with their sledges, ice chisels, and hooks, draw themselves up in battle array above the "*yatovcs*," or deep holes frequented by the fish, and at the firing of a cannon rush forward, select their spot, cut holes through the ice, and set themselves at work with rod and line, and in this way thoroughly glean the harvest of the river for many square miles in a day.

The sturgeon is cleansed by having the tail, head, and fins cut off, the belly cut open and eviscerated, the roe, swimming-bladder, and dorsal cord being carefully extracted. The body is then skinned, and the flesh sliced off longitudinally along the back-bone. After which the flesh is heavily salted, the sturgeons receiving on an average one-third their weight of salt. In general the larger species of sturgeon remain in salt nearly six months, when they are like kench-cured codfish, washed out and slightly dried before being sent out to the trade.

CAVIAR.

We have already described the cleansing of the swimming-bladders of this fish for making isinglass, and the preparation of the glutinous spinal cord for "*vesiga*" or fish-cakes, but the subject of caviar deserves a little more detail and attention. The roe of the sturgeon differs materially from that of other fish, in being of large size and very thin skinned, containing only an oily jelly, which melts away in the mouth, having little or no residuum, and these are held together by a net-work of cellular tissue, fat, and muscle in large masses, which generally exceed in size the head of the largest man.

A net of very small mesh, spread over a frame, does duty as a kind of coarse sieve, and the roes being lightly pressed and kneaded over this, the eggs are detached and fall into wooden tubs placed below, each grain being of a very dark brown or black color, and utterly distinct from the others.

To make "grained caviar" the eggs are now sprinkled with salt ground very fine, of which from 3 to 5 pounds to thirty-six of eggs are used in the hotter months, while only 1¼ to 2½ pounds are sufficient in cold weather, the least possible quantity of salt being a great desideratum. A wooden fork with from eight to ten prongs is used to stir in the salt, and the eggs become first doughy, then swell, and finally give out a noise like the stirring of small scales of glass, a sure proof that the process is completed, after which the caviar is close packed in hard-wood kegs.

In making "grain caviar" the eggs fall into tubs of brine stirred as before, and in lots of about one hundredweight subjected to heavy pressure in coarse sacks, until the brine is expelled and the whole compressed into a cheesy mass.

Nearly one-third of the contents of the eggs are pressed out with the brine, and the caviar thus made is packed in large casks lined with napkin linen, from whence it is called *caviar a la serviette* or "napkin caviar."

Caviar a sac, as its name denotes, is choice pressed caviar, put up in linen sacks, and other choice preparations are shipped in hermetically sealed cans and boxes.

The fattest caviar made in midsummer is merely soaked in brine and packed without pressing, in casks holding from 180 to 360 pounds each. Much roe which is tender to the touch and half spoiled is soaked in very strong brine, packed in large casks holding from 900 to 1,000 pounds, and is worth only from six to eight cents per pound, while the fat summer caviar brings from twelve to eighteen cents.

The choice kinds of fresh grain caviar packed in small kegs costs in Astrachan from sixty to seventy cents per pound, while the pressed brings but about forty-five to forty-eight cents, while that of the "sterliad" and some especially choice makes are never exported.

Nearly 400,000 pounds are annually sent from Astrachan to Berlin, Dresden, and Vienna, and England uses nearly $10,000 worth yearly, but in this market but little is used except by foreigners, who have contracted a taste for it elsewhere.

AMERICAN SPECIES.

The sharp-nosed sturgeon (*Acecipenser oxyrhynchus*), and the short-nosed sturgeon (*Acecipenser brevirostris*), range from Florida to the mouth of the St. Lawrence, and are fast becoming a staple article of food as far north as New York city, where the firms controlling this little known American fishery reside.

But few there are east of Hellgate who would deign to touch a morsel of this huge armor-plated fish, whose dead body has often been covered up on the compost heap, or left to rot upon the sand, when accidently taken in the weirs or nets of our fishermen.

To nearly all New Englanders it is a piece of strange news that the meat of this curious looking fish is by many esteemed superior to that of the salmon, either fresh or smoked, and the swimming-bladder itself, which in the druggists' hands should be worth from $3.00 to $4.00 in a huge specimen, is seldom preserved and never properly prepared. As to caviar, the less said the better, for few even of our most noted epicures have seldom acquired a taste common to all continental *bon vivants*.

But the fishery of the American sturgeons has long been carried on by a few firms who have quietly concealed the extent and value of their operations from the public, and who have at last built up a demand for sturgeon flesh which requires from 2,000,000 to 3,000,000 pounds a year to meet the demand, and at an average price of four cents per pound at wholesale, and it ranges from two to seven cents, makes the value of the flesh, as paid to the two or three leading firms in the business in New York city, about $120,000 annually.

The fishing begins in March, as far south as the Altamaha and Ogeechee rivers in Georgia, and as the season advances they are taken in the Edisto, Santee, Pedee, Cape Fear, Neuse, Tar, Roanoke, Chowan, and the Potomac and its tributaries. By the first of April the fishery is in full operation in the Delaware, and later on the Hudson. Merrimack, Kennebec, Penobscot, and other rivers contribute their share. A single fishing near Wilmington, Del., employs from fifty to sixty men, who take the sturgeons in set nets of large sized mesh, the fish taken averaging from fifty to sixty pounds, but sometimes reaching two hundred. The nets are watched, and when the floats are seen to go down the sturgeon are secured by means of a thong around the gills, and as they are not easily killed they are usually placed alive in a "pen," or floating car, from whence they can be taken when needed.

When a shipment is to be made, the fish are killed by beheading, the tail is chopped off, the fish eviscerated and skinned, and the flesh taken off in huge slabs, the large, keen knives used cutting close to the spinal column. These slabs are again divided until of a size to pack well in barrels or boxes with crushed ice, and are sent to the Philadelphia, New York, and Albany markets. The flesh is sold fresh or goes to the smokers, who, after salting it about three hours, dry and lightly smoke the same, producing an article which, in the New York market, is held equal, if not superior, to salmon similarly prepared.

The bones, skin, head, etc., are boiled down to procure a deep colored and very pure oil, well adapted to machinery, and worth, by the barrel, about thirty cents per gallon, at the present writing, and the swimming bladder is carefully prepared and dried, to be sold as Russian isinglass in the Old World, although some American isinglass has of late brought as high as $2.50 per pound in New York.

Caviar to the amount of some 2,000 packages, in the shape of small kegs of hardwood, containing from eighteen to twenty pounds of "grain caviar," are exported yearly from New York, making about 40,000 pounds, worth on an average fourteen cents per pound, or $5,600, most of which goes to Germany. The home demand is, however, decidedly on the increase, for few who once bring themselves to eat the jetty globes of glutinous jelly ever care to refuse at the second asking, and, like tomatoes, the liking grows to be almost a passion when once indulged in.

Although the great lakes and western rivers abound with these fish, and they are taken to a greater or less extent all along the Atlantic coast by those engaged in taking sea fish, the interest centers in a few cities, and New York, with its cosmopolitan population and tastes, is the great center of consumption.

The armor scales of the sturgeon, which are hard, strong, and of huge size, have been used by savage tribes for pointing their weapons, making rude cutting tools and personal ornaments; and the skin is strong and capable of tanning into a light waterproof leather, which, like that of the alligator, is reticulated by the removal of the scales.

Around the shores of Cape Cod in former years, the fish, although never eaten, was hunted for use in the compost heap and its oil, and in a manner which, owing to the strength and size of the fish, was most exciting in its nature. Provided with a sharp harpoon of suitable size and shape, attached by a short rope to a stout, water-tight keg, the fisherman poled gently across the flats where the sturgeons were found at flood tide moving slowly along and gleaning the various sea slugs, worms, shellfish, etc. When near enough, the iron was thrown or struck into the fish, and the keg and line thrown overboard, while the wounded fish, at its greatest speed, darted out into deep water, and in great circles swam round and round until worn out with its efforts and loss of blood.

Roger Williams, in his "Key to the Language of New England," 1643, says that the sturgeon was known by the name of Kauposh-Shauog, and observes: "Divers parts of the country abound with this fish, yet the natives for the goodnesse and greatnesse of it much prize it, and will neither furnish the English with so many, nor so cheap, that any great trade is likely to be made of it untill the English themselves are fit to follow the fishing. The natives venture one or two in a Canow, and with a harping Iron, or such like Instrument, sticks this fish, and so take it into their Canow. Sometimes they take them in their nets, which they make strong of Hempe."

So powerful is the fish that a single blow of its tail would readily break a man's leg or arm, and its speed at times is something wonderful to witness, while its graceful leaps, when ascending a river, have almost become proverbial.

A NOVEL EQUIPAGE.

As the sturgeon is a fish able to bear considerable handling, and very powerful, one or more have several times been trained to draw boats, being like the white whales, driven in aquarium tanks, harnessed to the boats by means of a strong and closely fitting rubber band, placed just behind the pectoral fin. A gentleman in Pennsylvania, living near Lehigh, drives a pair kept apart by an ashen pole about eight feet long, whose ends fit into brass rings on the top of the band, and also by a similar but lighter pole attached to smaller bands behind the dorsal fin. As the fish were very powerful, and there was some danger of their drawing the boat under, large floats, in the shape of swans, nicely painted, were made and attached to the harness rings, keeping the fish about three feet below the surface.

They are guided by means of a goad, whose point projects at right angles from the pole, with which the fish are pricked on the opposite side from the course desired, touched behind to accelerate their speed, or on the nose to bring them to a stop.

As the boat is in the form of a shell, and the swans are seemingly guided by a pair of gay reins, the general effect is very striking, and the speed attained almost equal to that of trained horses on a good road.

We hope that our eastern readers, especially those interested in the fisheries on the south coast of New England, will remember in future that in the New York market fresh sturgeon is worth from two to seven cents per pound, and that the swimming bladder, roe, and oil, are all salable products. Caviar, however, must be made with very soft pure salt, and that of Luneburg alone is deemed fit for this purpose by the present American manufacturers, although Cagliari might, we think, do equally well, in case the other cannot be procured.—*Boston Journal of Commerce.*

One hundred and eighty-three cotton mills have been built in the South since the war.